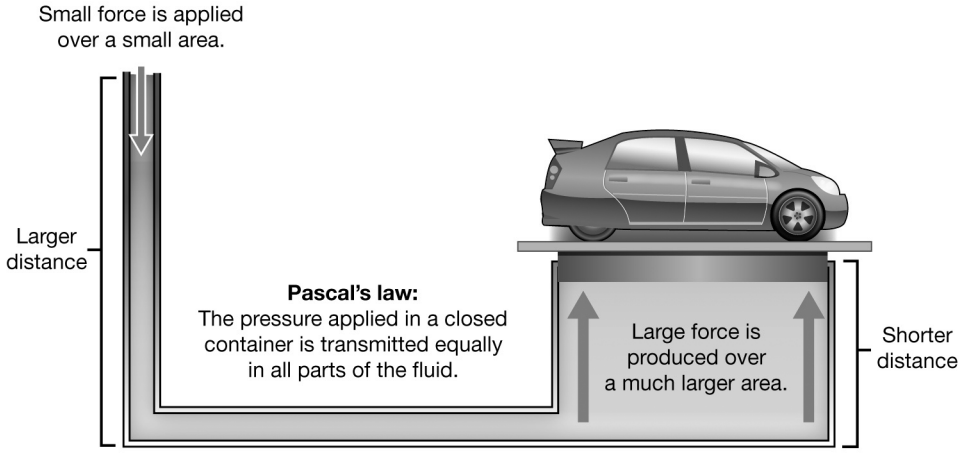
Name: _____ Date: _____

CONTENT 10.3

10.3 Pressure in Fluids

READ CPO Science

Have you ever wondered how a 1,500-kilogram car is raised off the ground in a mechanic's shop? A hydraulic lift does the trick. All hydraulic machines operate on the basis of Pascal's principle, which states that the pressure applied to an incompressible fluid in a closed container is transmitted equally in all parts of the fluid.



A small force exerted over a large distance is traded for a large force over a small distance.

In the diagram above, a piston at the top of the small tube pushes down on the fluid. This input force generates a certain amount of pressure, which can be calculated using the formula:

$$Pressure = \frac{Force}{Area}$$

That pressure stays the same throughout the fluid, so it remains the same in the large cylinder. Since the large cylinder has more area, the output force generated by the large cylinder is greater. The output force exerted by the piston at the top of the large cylinder can be calculated using the formula:

$$Force = Pressure \times Area$$

You can see that the small input force created a large output force. But there's a price: The small piston must be pushed a greater distance than the large piston moves. Work output (output force × output distance) can never be greater than work input (input force × input distance).

EXAMPLE

- A 50.-newton force is applied to a small piston with an area of 0.0025 m^2. What pressure, in pascals, will be transmitted in the hydraulic system?

Solution:

$$Pressure = \frac{Force}{Area} = \frac{50.\ \text{N}}{0.0025\ \text{m}^2} = 20000\ \text{Pa}$$

- The area of the large cylinder's piston in this hydraulic system is 2.5 m^2. What is the output force?

Solution:

$$Force = Pressure \times Area = 20000\ \text{Pa} \times 2.5\ \text{m}^2 = 50000\ \text{N}$$

PRACTICE

1. In a hydraulic system, a 100.-newton force is applied to a small piston with an area of 0.0020 m^2. What pressure, in pascals, will be transmitted in the hydraulic system?

2. The area of the large cylinder's piston in this hydraulic system is 3.14 m^2. What is the output force?

3. An engineer wishes to design a hydraulic system that will transmit a pressure of 10,000 pascals using a force of 15 newtons. How large an area should the input piston have?

4. This hydraulic system should produce an output force of 50,000 newtons. How large an area should the output piston have?

5. Another engineer is running a series of experiments with hydraulic systems. If she doubles the area of the input piston, what happens to the amount of pressure transmitted by the system?

6. If all other variables remain unchanged, what happens to the output force when the area of the input piston is doubled?

7. If the small piston in the hydraulic system described in problems 1 and 2 is moved a distance of 2 meters, will the large piston also move 2 meters? Explain why or why not.

8. A 540-newton woman can make dents in a hardwood floor wearing high-heeled shoes, yet if she wears snowshoes, she can step effortlessly over soft snow without sinking in. Explain why, using what you know about pressure, force, and area.