13.3: Pascal's Law


Figure 10.3.1

A person is able to lift the entire rear end of the automobile using only one hand with the hydraulic jack shown in the image. Hydraulic systems are similar to simple machines in that they can produce very large mechanical advantages.

Pascal's Principle

The earth's atmosphere exerts a pressure on all objects with which it is in contact. Atmospheric pressure acting on a fluid is transmitted throughout that fluid. For example, the water pressure at 100. m below the surface of a lake is 9.8×10^5 Pa. The total pressure at that point, however, is the pressure of the water plus the pressure of the air above the water. The pressure of the air at the surface of the water is 1.0×10^5 Pa, or 1 atm (atmosphere). Therefore, the total pressure at 100. m below the surface of the water is 9.8×10^5 Pa + 1.0×10^5 Pa = 10.8×10^5 Pa.

This is an example of **Pascal's Principle**, which states that pressure applied to a confined liquid increases the pressure throughout by the same amount. A number of practical devices take advantage of this principle. Hydraulic brakes, **hydraulic lifts**, and hydraulic presses are three useful tools that make use of Pascal's Principle.

The sketch below is an example of a hydraulic lift. We have a confined liquid in contact with two pistons (A and B) of different sizes. The pressure of the liquid on these two pisons is the same (Pascal's principle). Therefore, FA=FB,

and $F_A/A_A=F_B/A_B$ *and* $F_A/F_B=A_A/A_B$.

Suppose that the area of piston A is 4.0 cm^2 and the area of piston B is 200. cm^2. If we place an automobile weighing 10,000 N on piston B, we can lift that car by exerting a force of 200 N on piston A. This is another form of simple machine and its ideal mechanical advantage is 50. The ideal mechanical advantage of a hydraulic lift equals the ratio of the large piston area to the small piston area.

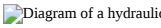
Figure 10.3.2

It can be really dangerous if tires are under inflated or over inflated, so it is important to be precise when it comes to measuring tire pressure. Use the simulation below to experiment with different inflation pressures for truck tires:

Summary

- Atmospheric pressure acting on a fluid is transmitted throughout that fluid.
- Pascal's Principle states that pressure applied to a confined liquid increases the pressure throughout by the same amount.

Review

1. In a hydraulic lift whose input line has a cross-sectional area of 1.00 cm^2 and whose output line has a cross-sectional area of 20.0 cm^2, what is the largest mass (kg) that can be lifted by an input force of 1000. N?
2. In a hydraulic lift whose IMA is 50, how far (ideally) will the output platform be lifted when the input platform is depressed 100. cm?
3. A 20.0 N force is exerted on the small piston of a hydraulic system. The cross-sectional area of the small piston is 0.0500 m^2. What is the magnitude of the weight than can be lifted by the large piston, which has a cross-sectional area of 0.100 m^2?

Explore More

Use this resource to answer the questions that follow.

1. What property of liquids allows for the great mechanical advantage of a hydraulic lift?
2. If the ratio of A2 to A1 was 100, what force would be required to lift a 10000 N car?

Additional Resources

Real World Application: Pascal's Principle

Video: