

Grade 8 Science Fluids – Pressure, Pascal's Law and Hydraulic Advantage

Name: Answers Class: _____ Date: _____

What is pressure?

Pressure is the amount of force that is applied to a given area.

What is PSI?

Pounds per square inch – a measure of pressure.

What is 1 Pascal equal to?

1 Pascal (Pa) is equal to 1 N per square metre.

The conversion factor from PSI to Pa is 6894.757Pa/PSI

Why is liquid ideal for hydraulics?

Liquids are used for hydraulics since they flow and are incompressible (They transfer force well).

Why are gases not good for hydraulics?

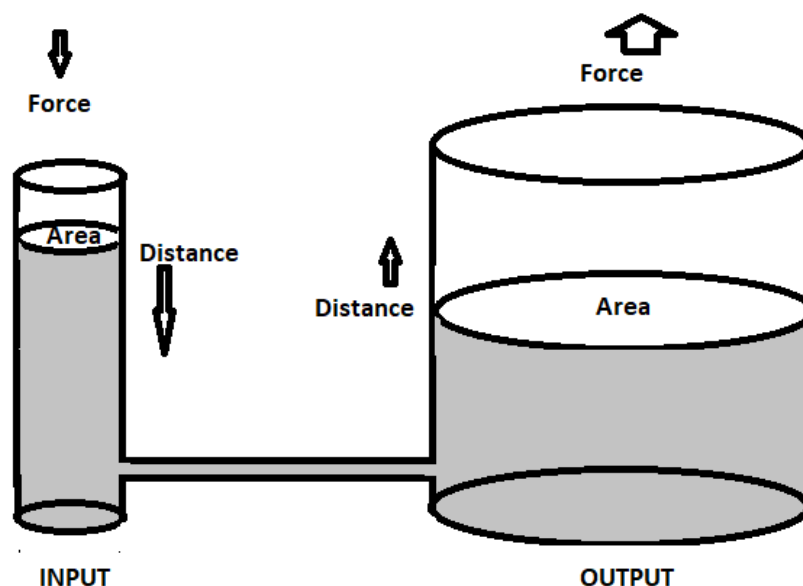
Gases are not good at hydraulics because they compress and do not transfer force well. (They are good at pneumatics though.)

Why are solids not good for hydraulics?

Solids are not capable of flow and therefore are not good at closed systems needing flow.

How do we create Hydraulic Advantage in a closed system?

We create a closed system of liquid with two pistons of different areas. This means that the pressure in the system pushes with a greater overall force on the larger piston since it has a greater area with the same pressure. If the pressure is 10 PSI in a system and the smaller piston has 1 square inch, the force on the piston is 10 pounds but if the other piston is 10 square inches, that would be 10 times the area and 10 times the force – 100 pounds of force – this creates hydraulic advantage.



How do we calculate Hydraulic Advantage? What three ways can we calculate Hydraulic Advantage?

1 – SAR **Surface area ratio (Piston out : Piston in)**

(HA = Output Area ÷ Input Area)

2 – SR **Distance (Speed) ratio (Piston in : Piston out)**

(HA = Input Distance ÷ Output Distance)

* - Note – This is opposite than the other two

3 – MA or HA **Force Ratio (Force Out : Force In)**

(HA = Output Force ÷ Input Force)

Once you find one ratio or have the Hydraulic Advantage (also known as Mechanical Advantage), you can calculate the other part of each ratio:

$$\text{Hydraulic Advantage} = \text{Mechanical Advantage} = \underset{\text{MA or HA}}{F_{\text{out}} : F_{\text{in}}} = \underset{\text{SAR}}{A_{\text{out}} : A_{\text{in}}} = \underset{\text{SR}}{D_{\text{in}} : D_{\text{out}}}$$

Use this information and the work on the board to answer the following questions.

1. What is the Hydraulic Advantage of a system with an input piston with an area of 3 cm² and an output piston of 27 cm²?

$$\begin{aligned} \text{HA} &= A_{\text{out}} \div A_{\text{in}} \\ &= 27 \text{ cm}^2 \div 3 \text{ cm}^2 \quad \text{units Cancel Out} \\ &= 9 \end{aligned} \quad \therefore \text{The Hydraulic Advantage is 9.}$$

What is the Hydraulic Advantage of a system that raises the output piston a distance of 2.5 cm when the input piston moves 50 cm?

$$\begin{aligned} \text{HA} &= D_{\text{in}} \div D_{\text{out}} \\ &= 50 \text{ cm} \div 2.5 \text{ cm} \quad \text{units Cancel Out} \\ &= 20 \end{aligned} \quad \therefore \text{The Hydraulic Advantage is 20.}$$

If an input force of 40 N creates an output force of 960 N, what is the hydraulic Advantage?

$$\begin{aligned} \text{HA} &= F_{\text{out}} \div F_{\text{in}} \\ &= 960 \text{ N} \div 40 \text{ N} \quad \text{units Cancel Out} \\ &= 24 \end{aligned} \quad \therefore \text{The Hydraulic Advantage is 24.}$$

If the Hydraulic Advantage is 7 and the input distance is 52.5 cm, what is the output distance?

$$\begin{aligned} \text{HA} &= D_{\text{in}} \div D_{\text{out}} \\ 7 &= 52.5 \text{ cm} \div D_{\text{out}} \quad (\text{Substitute Values}) \\ D_{\text{out}} \times 7 &= 52.5 \text{ cm} \quad (\text{multiply both sides by } D_{\text{out}}) \\ D_{\text{out}} &= 7.5 \text{ cm} \quad (\text{Divide both sides by 7}) \end{aligned} \quad \therefore \text{The output distance is 7.5 cm.}$$

If the area of the input piston is 1 cm² and you apply a force of 300N, what would be the output force if the area of the output piston is 12 cm²?

$$\begin{aligned} &\text{Set up Ratios since they are the same} \quad \text{Input : Output} \\ &\quad 1 \text{ cm}^2 : 12 \text{ cm}^2 \\ &\quad 300 \text{ N} : F_{\text{out}} \\ 1 \text{ cm}^2 \times F_{\text{out}} &= 300 \text{ N} \times 12 \text{ cm}^2 \quad (\text{cross multiply}) \\ F_{\text{out}} &= 3600 \text{ N} \times \text{cm}^2 / 1 \text{ cm}^2 \quad (\text{divide by } 1 \text{ cm}^2) \\ F_{\text{out}} &= 3600 \text{ N} \quad (\text{cm}^2 \text{ cancel out}) \end{aligned} \quad \therefore \text{Output force is 3600 N.}$$