

Topic 4 – Force, Pressure, and Area

Calculating Pressure

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

$$p = F / A$$

p is pressure **F** is Force and **A** is Area

The unit of measurement for pressure is a pascal (Pa), named after Blaise Pascal who did important research on fluids.

1 Pascal is equal to the force of 1 Newton over an area of 1 m²
1 Kilopascal is equal to 1000 pascals

Equipped Against Pressure

Safety equipment is needed in many situations in order to protect our body from injury or accident. Most of the safety equipment is designed *to spread the force over a larger area*.

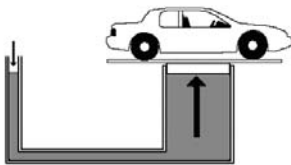
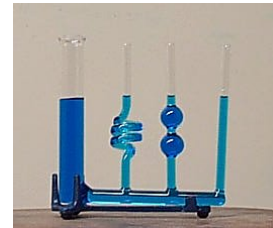
Pascal's Law

Blaise Pascal (1623-1662) discovered that ...

Pressure applied to an enclosed fluid is transmitted undiminished in all directions throughout the fluid and perpendicular to the walls of the container.

This is known as **Pascal's Law** and it makes **hydraulic** (liquid) and **pneumatic** (air) systems possible.

He was the first to notice that the shape of the container had no effect on the pressure at any given depth as illustrated here.



A common application of Pascal's law is the *hydraulic lift*.

It is a mechanical system that raises heavy objects, using a fluid under pressure in a *closed system* (self-contained collection of parts).

Pascal's Law and Mechanical Advantage

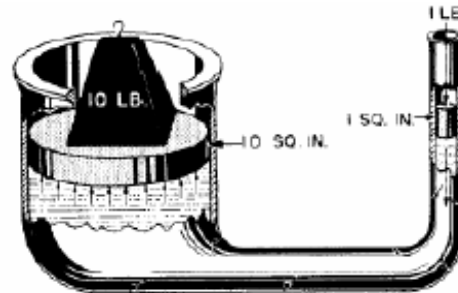
$$\text{Mechanical Advantage} = \frac{\text{Load Force}}{\text{Effort Force}}$$

In hydraulic systems, the pressure is created using a piston. Pistons can be different sizes and hydraulic devices use pistons that are different sizes attached to each other with a flexible pipe. The **Input piston** is used to apply force to the fluid, which creates pressure in the fluid. The fluid transfers this pressure to the **output piston**. This pressure exerts a force on the output piston and the result is a mechanical advantage that makes the hydraulic system very useful.

The mechanical advantage in a hydraulic system comes from the fluid pressure in the system.

Calculating the input force and the output force will give you the Mechanical advantage of the system.

$$MA = \text{Output force} / \text{Input force}$$
$$MA = F_o x d_o / F_i x d_i \quad MA = 10 / 1 = 10$$



This hydraulic system has a mechanical advantage of 10

Mechanical advantages in hydraulic systems are usually quite high, showing how useful they are.

Pressure and Mechanical Advantage

The reason for the large mechanical advantage in a hydraulic system is the ability of the fluid to transmit pressure equally. It allows you to use a small force on the small piston to produce a larger force on the large piston.

$$p = F / A$$

From Pascal's law, we know that the pressure the small piston creates is the same everywhere in the fluid. So the large piston has a larger area and is able to multiply the pressure because of its larger area. The force and area at each piston act as ratios that have to be equal.

$$\frac{\text{Force of the small piston}}{\text{Area of the small piston}} = \frac{\text{Force of the large piston}}{\text{Area of the large piston}}$$

$$\frac{F_{\text{small}}}{A_{\text{small}}} = \frac{F_{\text{large}}}{A_{\text{large}}}$$

By solving this ratio you will find that the forces created within a hydraulic system provides very large mechanical advantages - making them useful in many applications.

Larger Force – Greater Distance To Move

Mechanical advantage in hydraulic systems has a cost. That cost is the increased distance the smaller force must go through to make the large force move a small distance.

***To increase the force on the output piston ,
the input piston must move through a greater distance.***



Amusement park rides make extensive use of hydraulic systems