# Hydraulics

## Flow Velocity

Flow velocity is the distance that fluid travels through a system in a given period. To solve for flow velocity, you must know the flow rate and area of the system.

| Flow Velocity Equation |
|---|
| Q = vA |
| Where:<br>Q = Flow rate, represented in gpm or in$^3$/min<br>v = Flow velocity, represented in ft/s or in/min<br>A = Area, represented in in$^2$ |

**Practice Problem**: A flowmeter attached to the main line in a hydraulic system measures the flow rate at 15 gpm. The line has an inside diameter of 2 inches. What is the flow velocity in the meter?

**TIP**: Convert gpm to in$^3$/min before solving. Recall that in the flow rate equation, 1 gallon = 231 in$^3$.

$$\frac{15\ gal}{min} \cdot \frac{23\ in^3}{1\ gal} = \frac{3465\ gal\ \cdot in^3}{1\ min \cdot gal} = 3465\frac{in^3}{min}$$

1. Use the given diameter value to solve for area.

$$A = \pi r^2$$

$$A = \pi(1^2)$$

$$A = 3.14\ in^2$$

2. Substitute the known values in the glow velocity equation and solve.

$$Q\ =\ vA$$

$$3465\ \frac{in^3}{min} =\ v\ (3.14\ in2)$$

$$v = \frac{3465\frac{in^3}{min}}{3.14\ in^2}$$

$$v\ =\ 1104\ \frac{in}{min}$$

## Bernoulli's Principle

Bernoulli's Principle states that an increase in velocity results in a decrease in pressure. Likewise, a decrease in velocity results in an increase in pressure. In Figure 1, a *venturi* illustrates Bernoulli's Principle. Venturi tubes are used in industrial and laboratory settings to measure the flow rate of liquid. In a venturi, fluid flows through a length of pipe with varying diameters. At the narrowed section of the pipe, the fluid speed increases and pressure decreases.

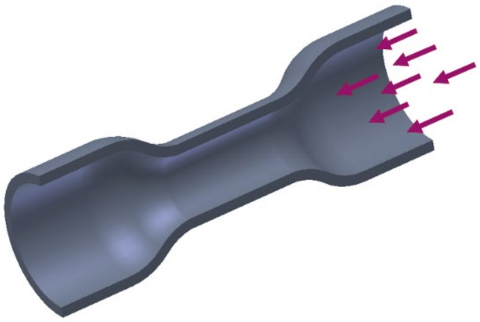

Figure 1. Split View of a Venturi

Bernoulli's Principle is important in hydraulic systems because the size of the piping or conduit will likely vary in design and impact the flow velocity. A hydraulic pump will create greater pressure at a lower flow rate, so if the flow is restricted at the pump due to smaller-size piping or conduit, the pressure in the system will increase.

## Mechanical Advantage

Hydraulic systems create a mechanical advantage by using fluid power to do work. Mechanical advantage is calculated by dividing the force at the output by the force at the input. To review these concepts, refer to **Simple Machines**.

**Practice Problem**: A force of 100 pounds is applied to the input cylinder of the hydraulic press in Figure 2.

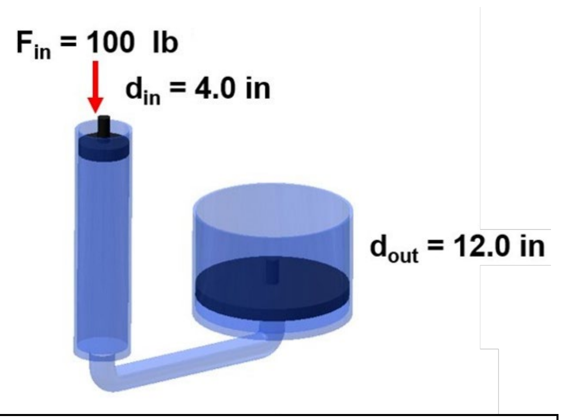


Figure 2. Hydraulic Press

 

What is the pressure in the system? How much force can the output cylinder lift? What is the mechanical advantage of the system?

1. Find the area of each cylinder.

| Input Cylinder | Output Cylinder |
|---|---|
| $A = \pi r^2$<br>$A = \pi(2.0r^2)$<br>$A = 12.57\ in^2$ | $A = \pi r^2$<br>$A = \pi(6.0^2)$<br>$A = 113.10\ in^2$ |

2. Find the pressure in the system.

$$P = \frac{F}{A}$$

$$P = \frac{100\ lb}{12.57\ in^2}$$

$$P = 7.96\frac{lb}{in^2}$$

3. Find the force that the output cylinder can lift.

$$P = \frac{F}{A}$$

$$7.96\ \frac{lb}{in^2} = \frac{F_{out}}{113.10\ in^2}$$

$$F_{out} = 7.96\frac{lb}{in^2}(113.10 in^2)$$

$$F_{out} = 900.28 lb$$

4. Find the mechanical advantage of the system.

$$MA = \frac{F_{out}}{F_{in}}$$

$$MA = \frac{900.28\ lb}{100\ lb}$$

$$MA = 9.0028$$

$$MA = 9$$

 