

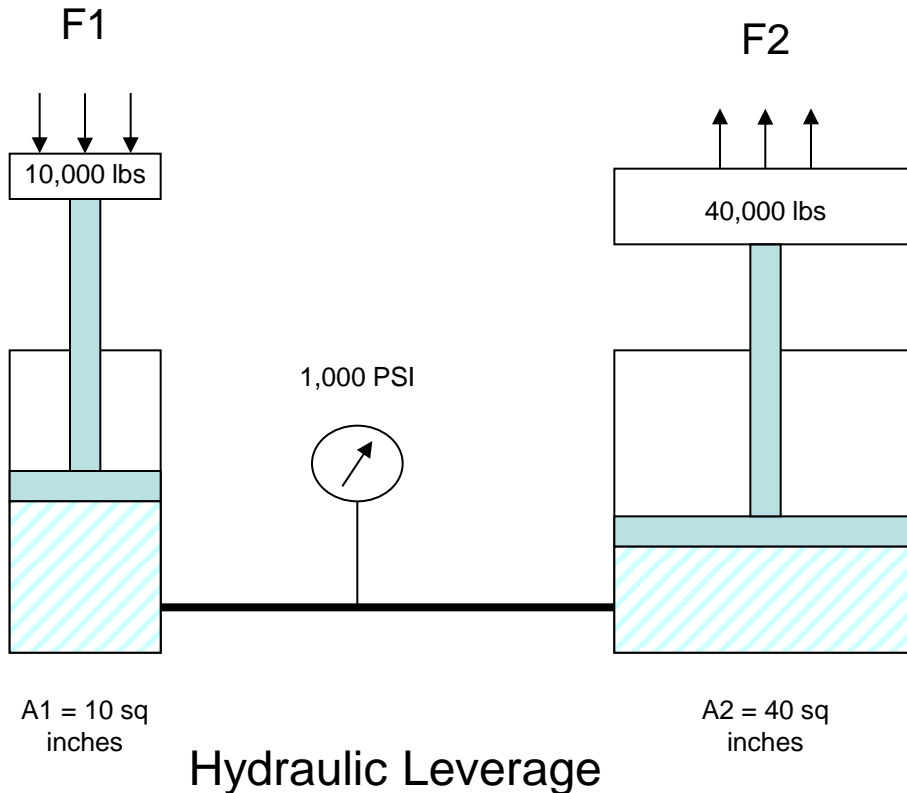
# Basic Fluid Power

## Definitions

Source: Fluid Power Basics, Hydraulics & Pneumatics Magazine

# Pascal's Law

Pressure in a confined body of fluid acts equally in all directions and at right angles to the containing surfaces.



$$F2 = F1 (A2 / A1)$$

$$F2 = 10,000\text{lbs} (40\text{sq in}/10\text{sq in})$$

$$F2 = 10,000\text{lbs} (4)$$

$$F2 = 40,000\text{lbs}$$

OR

$$P = F1 / A1$$

$$P = 10,000\text{lbs} / 10 \text{ sq in.}$$

$$P = 1,000 \text{ PSI (lbs / sq in.)}$$

THEREFORE

$$F2 = P * A2$$

$$F2 = 1,000 \text{ PSI} * 40 \text{ sq in.}$$

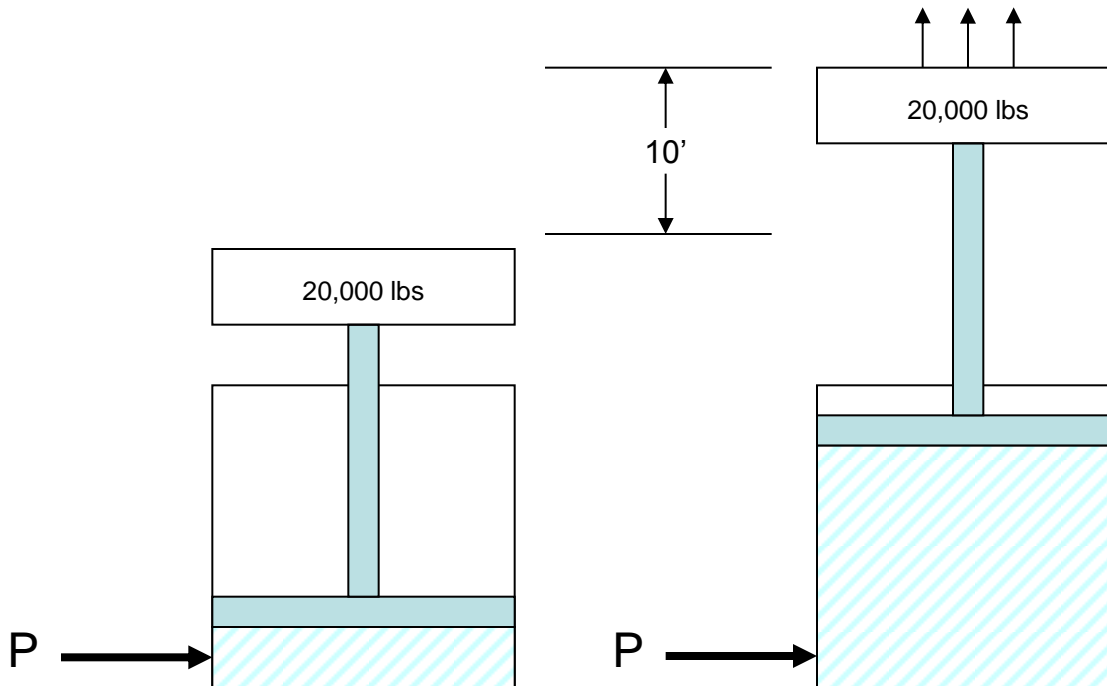
$$F2 = 40,000\text{lbs}$$

Pumps do not make pressure, they produce flow. Resistance to pump flow causes pressure.

# Work

Work is the force traversing through a distance.

Work = Force x Distance



Cylinder lifts a 20,000lb load a distance of 10'. The cylinder performs 200,000 ft-lbs of work.

$$W = F \times D$$

$$W = 20,000\text{lbs} \times 10'$$

$$W = 200,000 \text{ ft-lbs}$$

Time is not a factor in work.

# Power

Power is *work* done in a certain time.

$$\text{Power} = (\text{Force} \times \text{Distance}) / \text{Time}$$

Note:

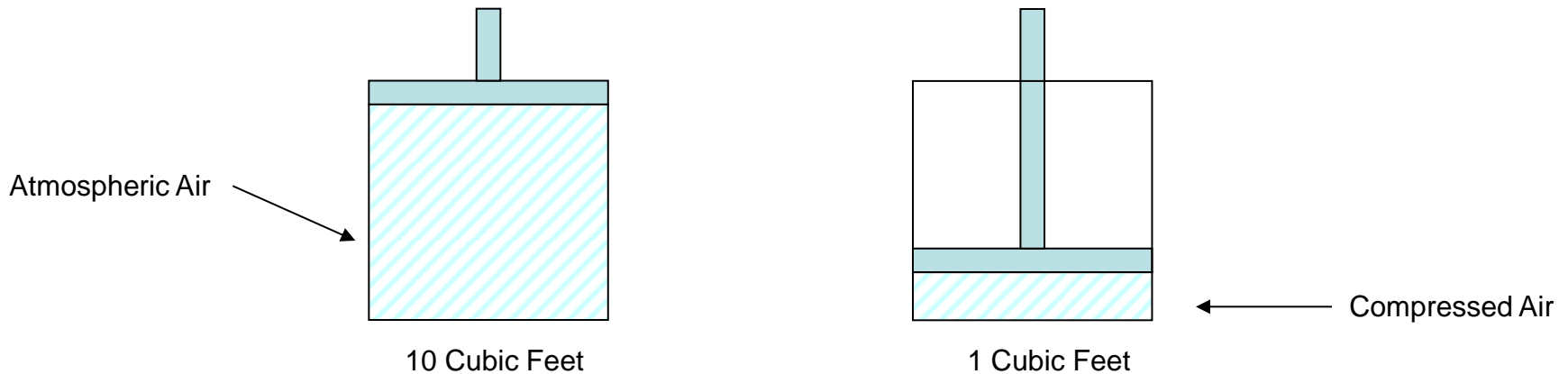
1. Common measure of Power is *Horsepower*
  - a) 1 HP = 33,000 Ft-lb / minute
2. Another measure of Power is Kilowatt
  - a) 1HP = 746 W

# Boyle's Law

For relatively low pressures, the absolute **pressure** of an ideal gas kept at *constant temperatures* **varies inversely** with the **volume** of the gas.

Which means:

If a 10 cubic foot volume of atmospheric air is squeezed into a one cubic foot container, pressure increases 10 times.



$10 \times 14.7 \text{ psia} = 147 \text{ psia}$  ← Atmospheric Pressure

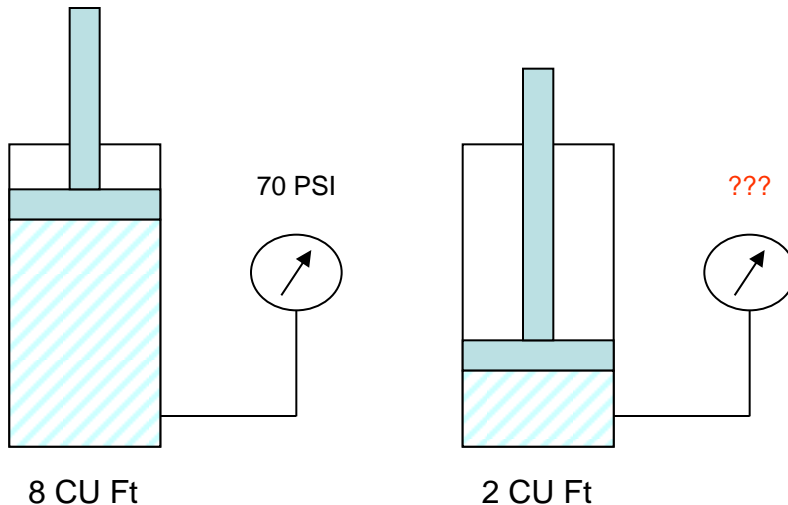
$147 \text{ psia} - 14.7 = 132.3 \text{ psig}$  ← Gauge Pressure

# Boyle's Law

## Sample Problem

### Problem:

What is the resulting pressure in PSIG for the following?



Notes:

1. Gauges read in PSI or BAR
2. BAR is equal to approximately the barometer reading or 1 atmosphere (14.696 psia)
3. SI unit for BAR is 14.5 PSI

Step 1: Calculate compression ratio

$$8 \text{ CU Ft} / 2 \text{ CU Ft} = 4$$

Step 2: Convert gauge pressure to PSIA

$$70 \text{ psig} + 14.7 \text{ psia} = 84.7 \text{ psia}$$

Step 3: Multiply compression ratio by PSIA

$$4 \times 84.7 \text{ psia} = 338.8 \text{ psia}$$

Step 4: Take out atmospheric pressure

$$338.8 \text{ psia} - 14.7 \text{ psia} = 324.1 \text{ psig}$$

## Charles's Law

The volume of a fixed mass of gas varies directly with absolute temperature, provided the pressure remains constant.

- Heating a gas or liquid causes it to expand.
- Continuing to heat a liquid will result in it changing to a gaseous state and perhaps spontaneous combustion.
- If a liquid or gas cannot expand because it is confined, pressure increases!

Therefore:

- Excessive heat can **damage** parts.
- Provide **relief valves** when heat might be an issue.
- Never heat or weld on any fluid power components without proper preparation of the unit.

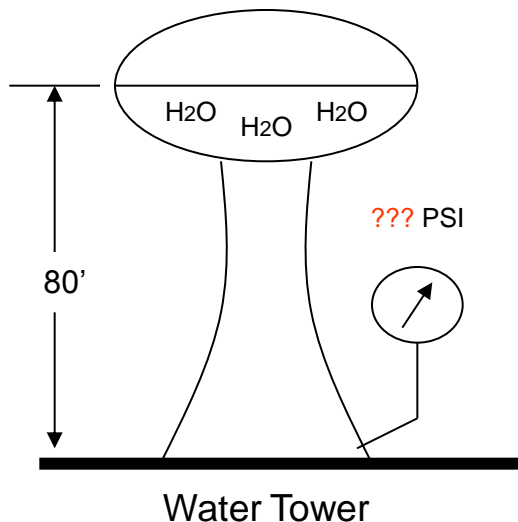
# Static Head Pressure

The pressure exerted on a container's sides and bottom caused by the weight of fluid in the container.

Caused by Earth's gravitational pull.

Problem:

What is the *static head pressure* at the base of the water tower?



**Constants:**

1 CU Inch of water = 0.0361 lbs

1 SQ inch column of water will exert a force of 0.0361 PSI for every inch of elevation.

**Therefore:**

$0.0361 \text{ PSI / Inch} * 12'' = 0.433 \text{ PSI / FT}$

**Answer:**

$\text{PSI at base} = 80' * 0.433 \text{ PSI / FT}$

$\text{PSI at base} = 34.6 \text{ PSI}$

**Size and shape of the vessel does not matter. The depth is what matters!**