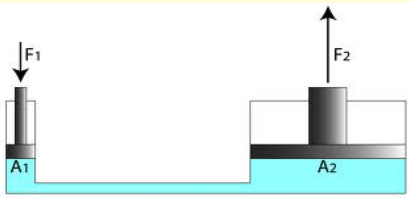
1.2 Pascal's Principle



Intro: fill a syringe with water, and see what happens when you pull the plunger out with the nozzle plugged.

Pascal's Principle

"Pressure applied to an enclosed fluid is transmitted undiminished to every point in the fluid and to the walls of the container."

$P_i = P_o$ Input pressure equals output pressure.

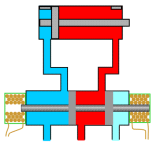
In incompressible fluids (water, hydraulic fluid), this happens instantaneously. In gases, the temperature and pressure change before reaching equilibrium (the principle still applies).

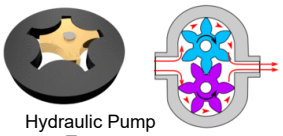
This is used extensively in machinery operation.

Hydraulics

Heavy equipment uses a hydraulic pump to move pressurized liquid to and from different parts of the machine through hoses.
At the end of the hoses are pistons which move in or out, depending on the position of hydraulic valves which the operator controls.
Syringe Demo.

Piston goes in or out.

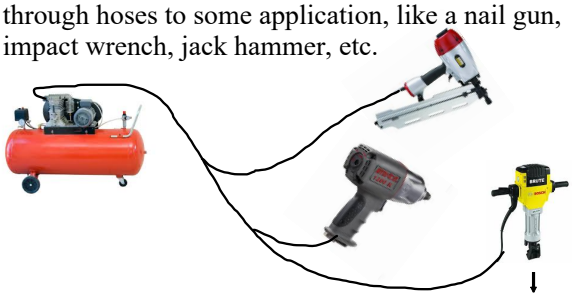




Hydraulic Pump Types

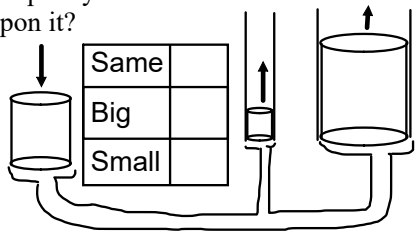
Pneumatics

Work similarly to hydraulics, but the working fluid is air, so there does not need to be a return line to the compressor: one way street (sound = psshhhhht!!).
A compressor pressurizes gas, which travels through hoses to some application, like a nail gun, impact wrench, jack hammer, etc.



1. Physics Democracy!

A system consists of an input cylinder connected to two output cylinders, a small one and a big one.
Pressure applied to the input cylinder transmits to the output cylinders.
Which output cylinder will have the most force acting upon it?
Vote!

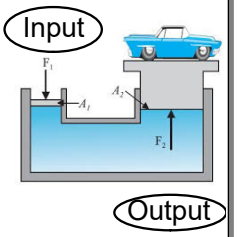


Hydraulic Lift Equation

By having different input and output areas of a hydraulic system, force can be multiplied using the following ratio:

$$\frac{F_i}{A_i} = \frac{F_o}{A_o}$$

F = Force (N)
A = Area (m^2)
i = input
o = output



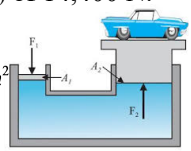
2. Hydraulic Lift Example A

A garage lift has input and lifting (output) pistons with radii of 5.0 cm and 15 cm, respectively.

The lift holds a car with a weight (m•g) of 14,400 N.

What is the force on the input piston?

Hint: convert to meters.



$$A_{circle} = \pi r^2$$

$$A_i = \pi \bullet (0.050\,m)^2 = 0.0079\,m^2$$

$$A_o = \pi \bullet (0.15\,m)^2 = 0.071\,m^2$$

$$\frac{F_i}{A_i} = \frac{F_o}{A_o}$$

$$F_i = \frac{A_i \bullet F_o}{A_o} = \frac{0.0079\,m^2 \bullet 14{,}400\,N}{0.071\,m^2} = 1{,}600\,N$$

3. Hydraulic Lift Example B

What pressure is applied to the input piston?

From the previous problem:

F_i = 1,600 N,

A_i = 0.0079 m^2,

$$P = \frac{F_i}{A_i} = \frac{1{,}600\,N}{0.0079\,m^2} = 2.0\ E5\,Pa$$

Homework 1.2

Preview 1.3

1.2 Booklet Problems
Due: Next Class

After: Build a hydraulic machine with the syringe set!