MENG2520 Pneumatics and Hydraulics

Module 1- Introduction to Fluid Power

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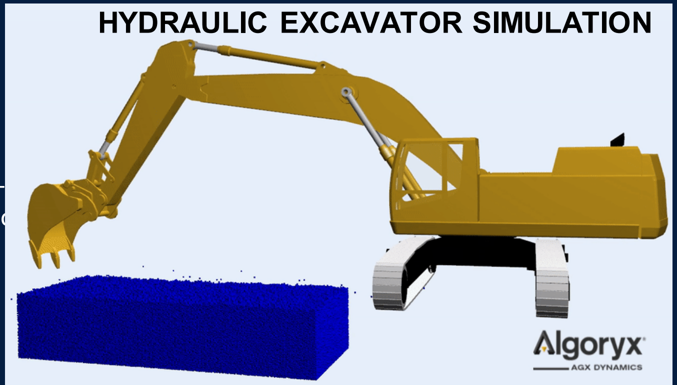
Introduction to Fluid Power

Hydraulic Power

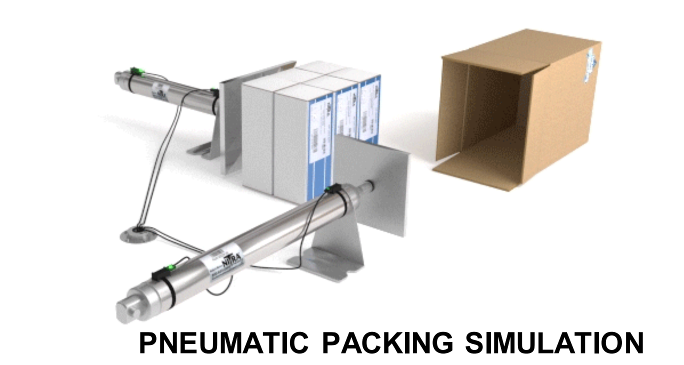
https://www.plantautomation-technology.com/products/yoruk-hydraulic-machine/monoblock-hydraulic-press-500-t

https://www.shearpowercorp.com/hydraulic-excavators.html

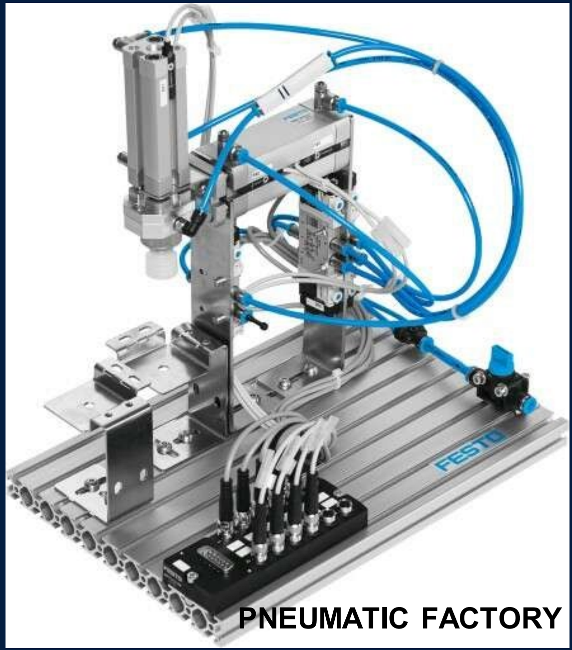


https://www.algoryx.se/heavy-vehicles/

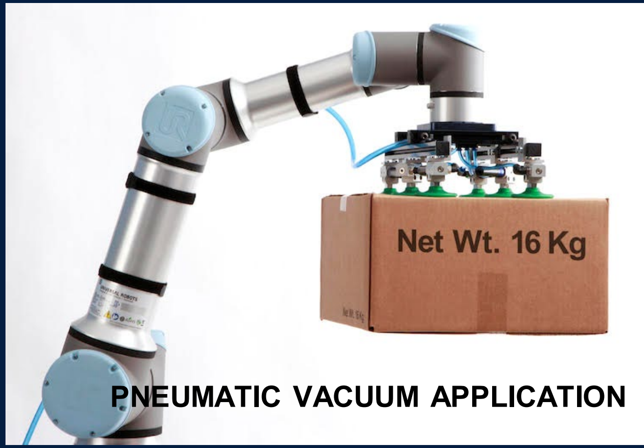
Pneumatic Power



https://library.automationdirect.com/pneumatic-actuator-air-cylinder-basics/



https://www.festo.com/us/en/e/technical-education/learning-systems/stem/meclab-r-id_32631/



https://roboticsandautomationnews.com/2020/01/02/how-to-choose-a-gripper-for-your-collaborative-robot/28075/

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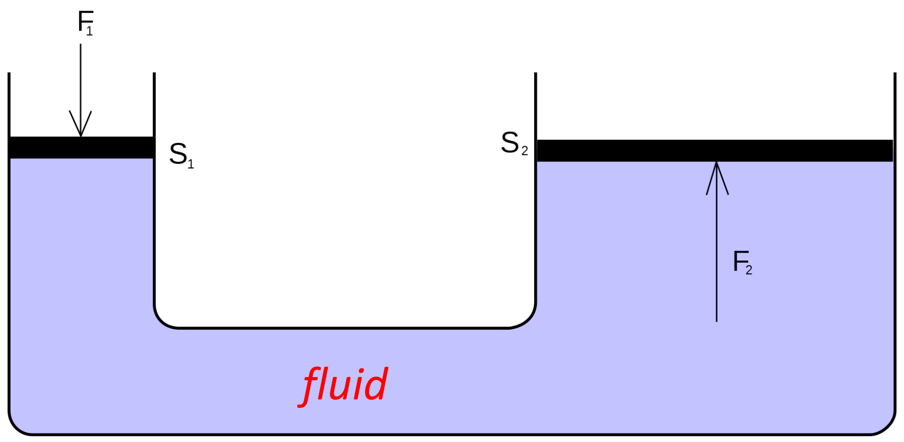
Fluid Power Definition

Fluid power is the use of fluids under pressure to generate, control, and transmit power.

Source: https://en.wikipedia.org/wiki/Fluid_power

Fluid power provides a means of Mechanical Transmission of Power.



A force F_1 exerted on surface S_1
is transferred through the *fluid*
resulting in
a force F_2 exerted on surface S_2

Fluid Power Definition

How can we operate that door from here?
What options do we have to impart a mechanical force from a remote location?

Electrical power?
Mechanical power?
Fluid power?

In a small group, come up with a (brief) design solution for each

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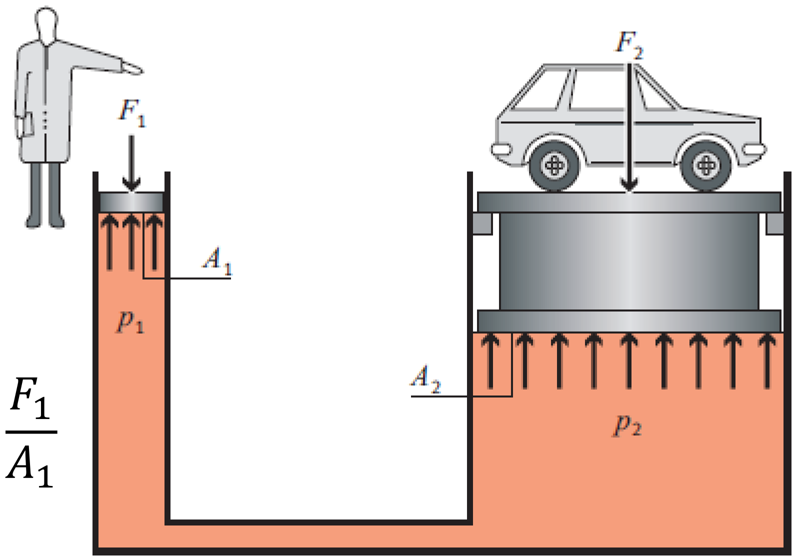
Fluid Power Power Transfer

Fluid power is the use of fluids under pressure to generate, control, and transmit power.

Source: https://en.wikipedia.org/wiki/Fluid_power



$$p_1 = \frac{F_1}{A_1}$$

$$p_2 = \frac{F_2}{A_2}$$

A force F_1 exerted on surface S_1 is transferred through the *fluid* resulting in
a force F_2 exerted on surface S_2

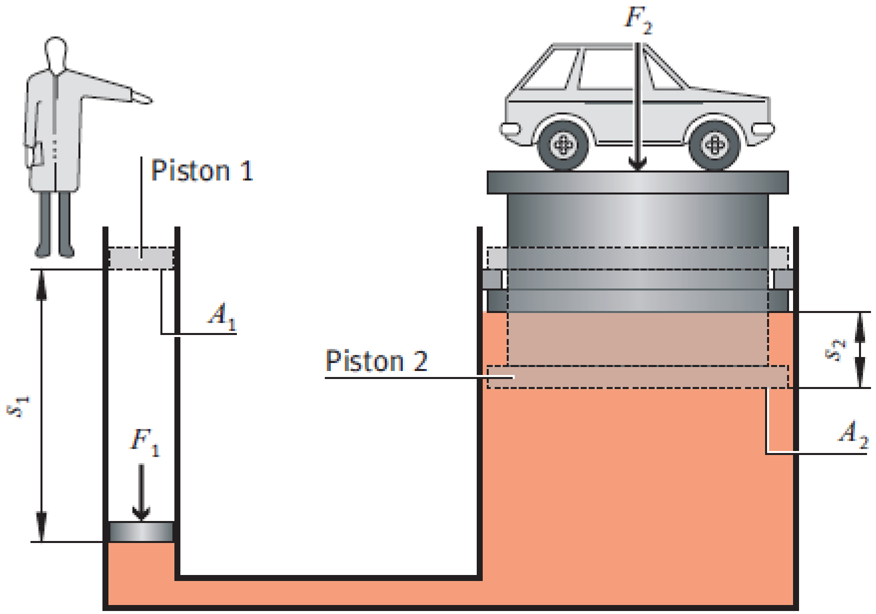
Pressure everywhere in a closed vessel is the same so $p_1 = p_2$ and therefore

$$F_2 = \frac{F_1 \times A_2}{A_1}$$

Since $A_2 > A_1$ then $F_2 > F_1$ which means the system results in force multiplier

Fluid Power Power Transfer

$V_1 = s_1 \times A_1$



$V_2 = s_2 \times A_2$

The volume V displaced is the same so $V_1 = V_2$ and therefore $s_2 = \dfrac{s_1 \times A_1}{A_2}$

Since $A_2 > A_1$ then $s_2 < s_1$ which means the system's <u>output displacement is less than the input</u>

Fluid Power Fluid

The *fluid* used is the key discriminator between the division of Fluid Power

Hydraulics

Oil
Water

https://www.powertransmissionworld.com/hydraulic-fluids-risks-of-fire-and-toxicity/

Pneumatics

Air
Other gasses

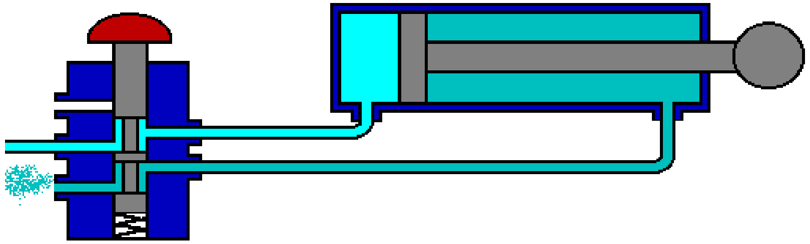
https://www.mybaggage.com/shipping/air/

Fluid Power Actuators

Actuators are divided into two groups: linear and rotary

Linear

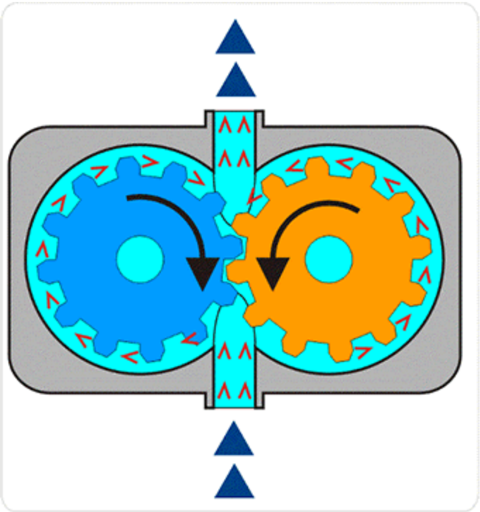
Most common form of actuator
Used in extension or compression



https://www.angelfire.com/ia3/jrtdogbone/pneumatic.htm

Rotary

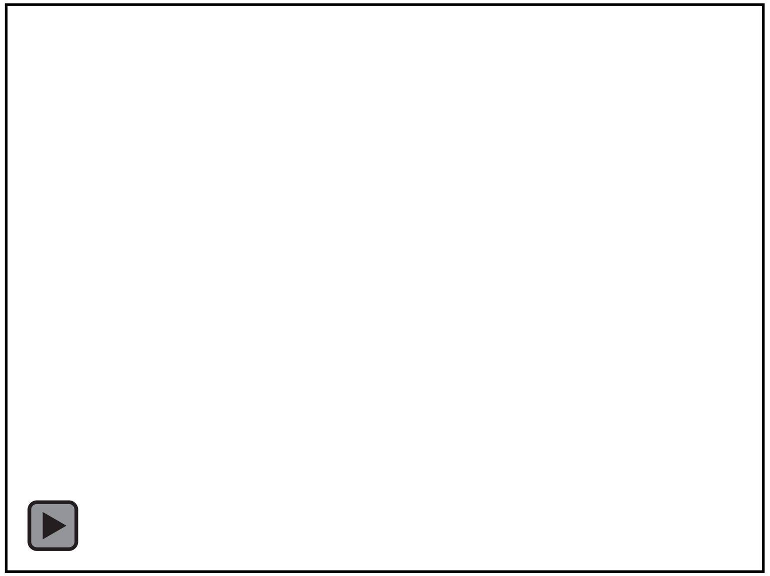
Also called motors
Creates a rotary force on the shaft



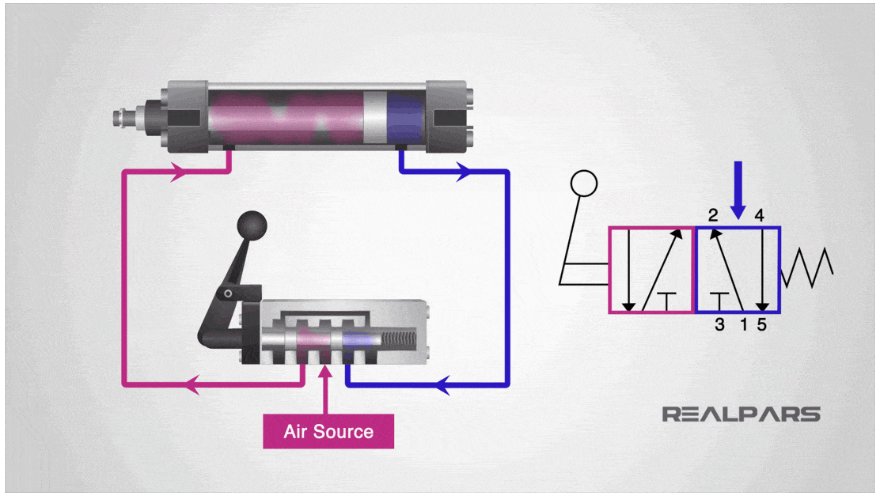
https://bestanimations.com/gifs/Rotary-Gear-Pump.html

Fluid Power Control

Fluid power control is achieved by directing the fluid to and from the actuators.
The principal device is a directional-control-valve, DCV



https://thumbs.gfycat.com/ElaborateElatedFowl-mobile.mp4

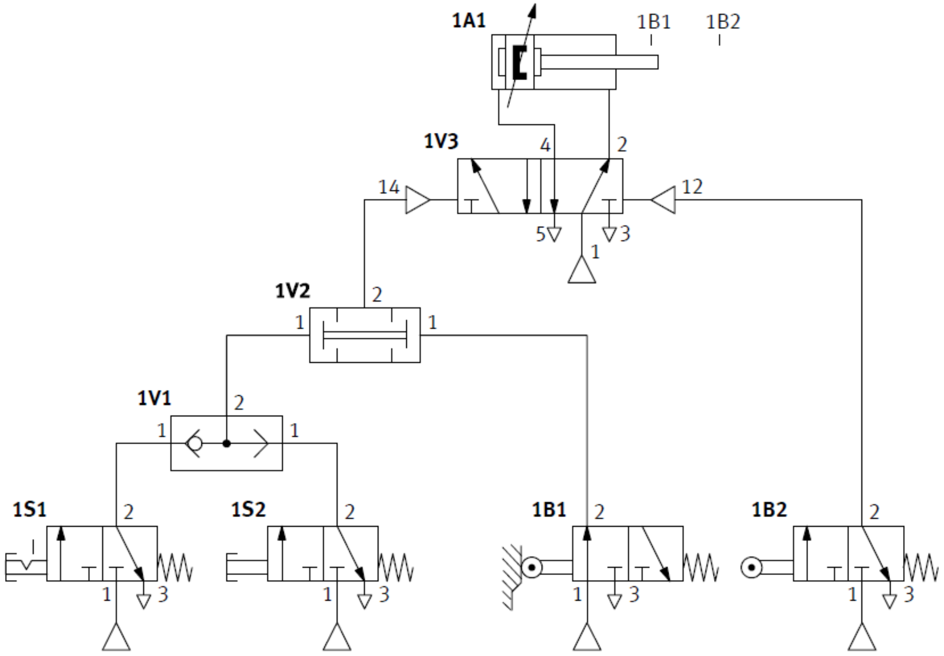


https://realpars.com/spool-valve-schematic/

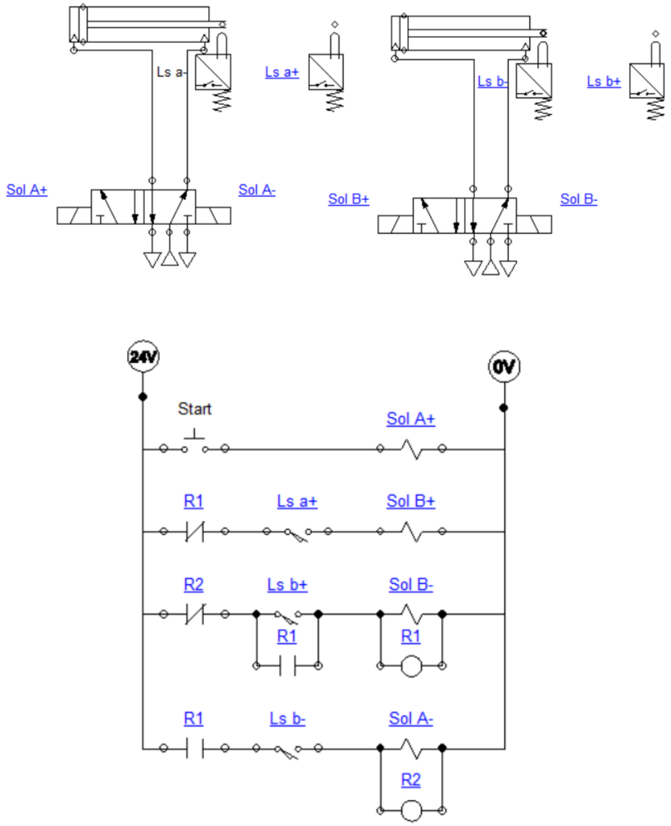
Fluid Power Control

Control valves can be manually actuated or automatic through fluid control or electrical control

Pure pneumatic/hydraulic control



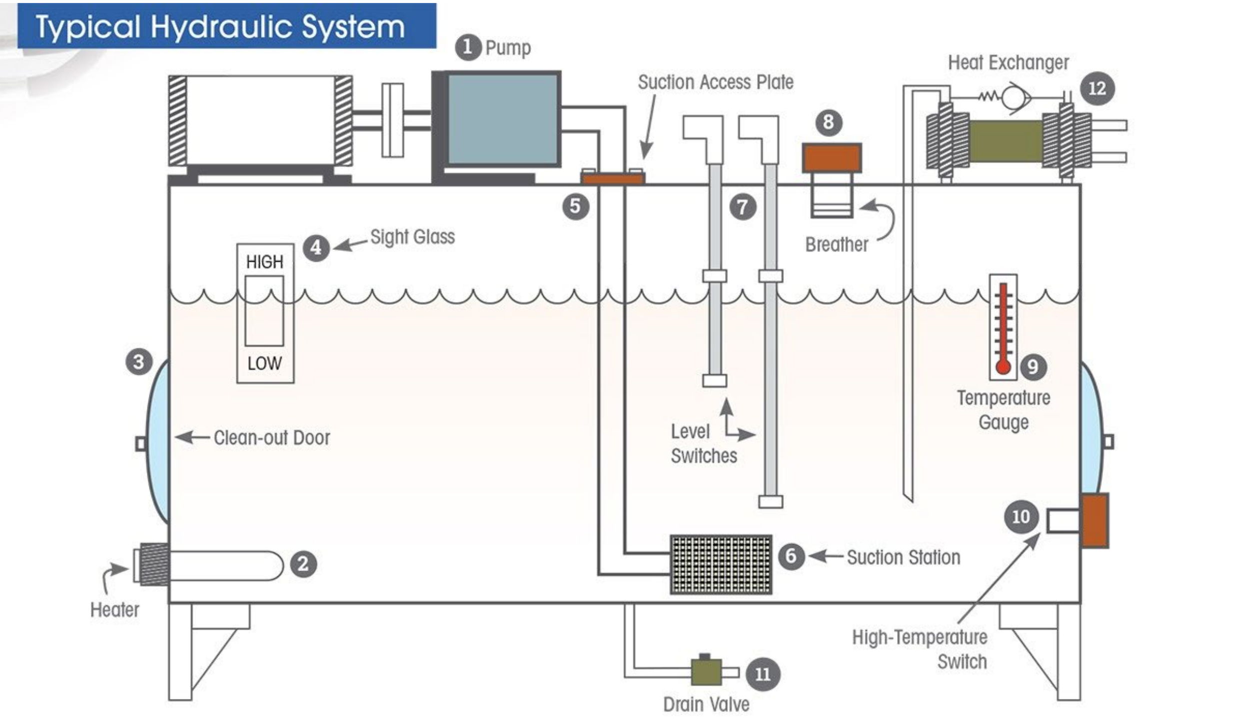
Electo-Pneumatic/hydraulic control



Fluid Power Fluid Preparation

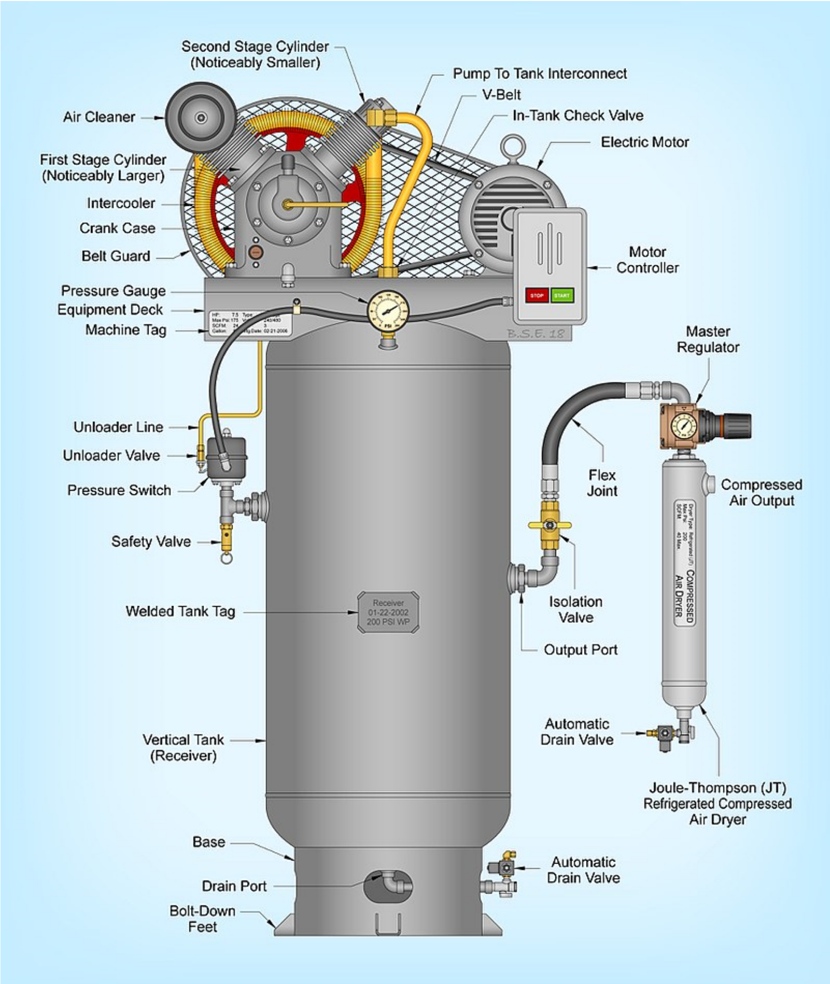
The *fluid* used in the system needs to ‘prepared’ which includes as a minimum compression and other ancillary components

Hydraulic pump and tank assembly



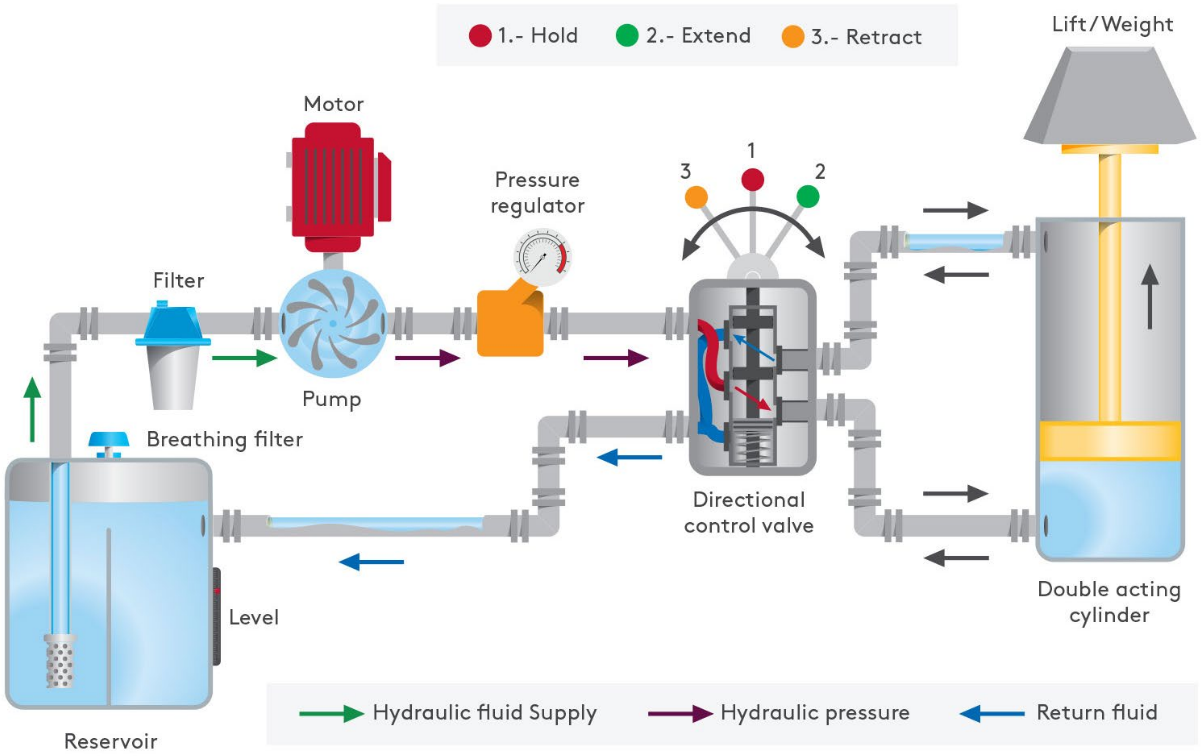
https://www.efficientplantmag.com/2015/04/improving-the-reliability-of-your-hydraulic-systems/

Compressor and Air Preparation Unit

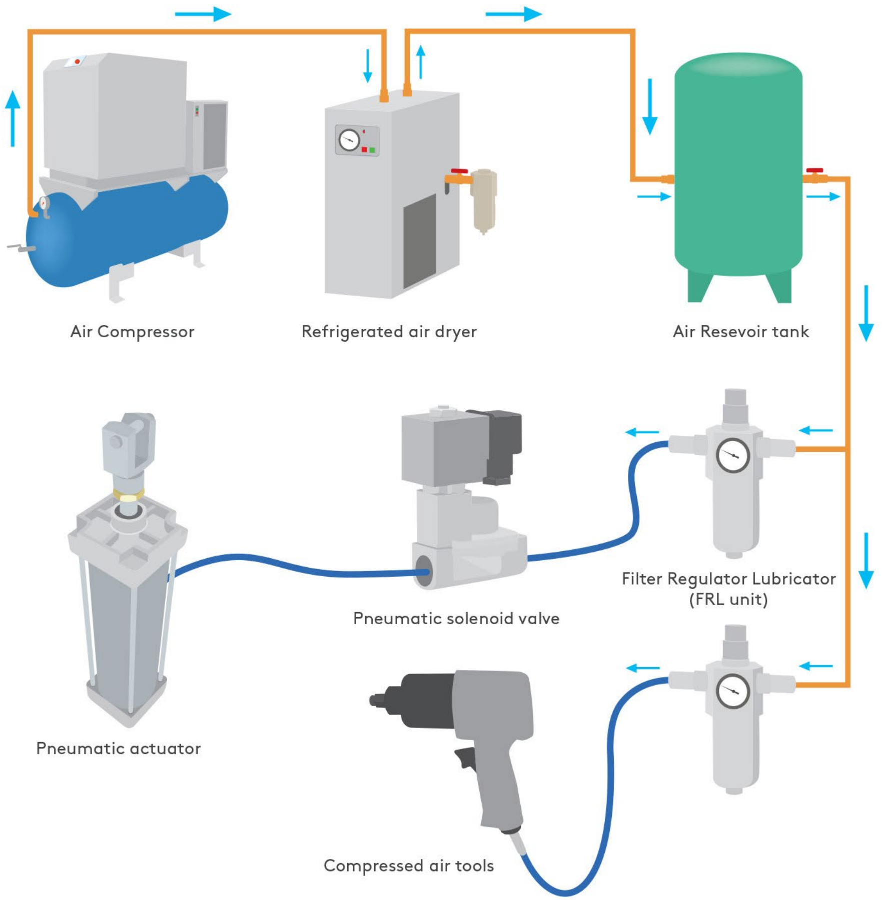


Fluid Power System

Typical Hydraulic System

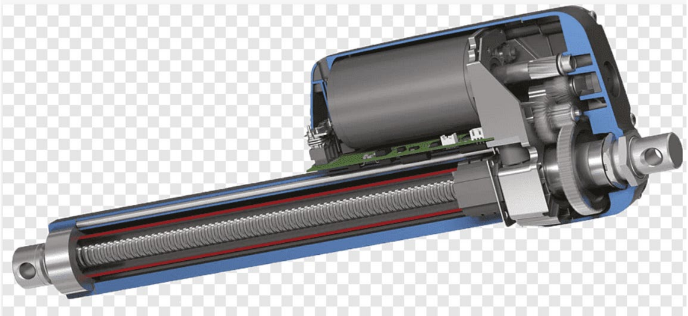


Typical Pneumatic System



https://www.essentracomponents.com/en-gb/news/guides/hydraulics-versus-pneumatics

Electrical VS Hydraulic VS Pneumatic



https://www.pngwing.com/en/free-png-mckkp

https://www.123rf.com/stock-photo/hydraulic_cylinder.html?sti=nmamel7ooc61wcjbxn|

https://www.youtube.com/watch?v=hmz1h5fk2bI

Electrical VS Hydraulic VS Pneumatic

	Electrical	Hydraulic	Pneumatic
Leakage	—	Contamination	No disadvantages except loss of energy
Environmental influences	Danger of explosion in certain area, temperature sensitive	Susceptible to temperature fluctuation, fire hazard in the event of leakage	Explosion-proof, temperature sensitive
Energy storage	Difficult, only in small quantities with batteries	Limited, with the help of gases	Lightweight
Energy transmission	Unlimited, with loss of energy	Up to 100 m flow velocity v = 2 to 6 m/s	Up to 1000 m flow velocity v = 20 to 40 m/s
Operating speed	—	v = 0.5 m/s	v = 1.5 m/s
Energy costs	Minimal	High	Very high
Linear motion	Difficult and expensive, small forces, speed can only be controlled at great expense	Easily accomplished with cylinders, good controllability of speed, very high forces	Easily accomplished with cylinders, limited forces, speed is very load-dependent
Rotary motion	Easy and powerful	Easy, high torque values, low rotational speeds	Easy, not very powerful, high rotational speeds
Positioning accuracy	Accuracies of down to ±0.05 mm and better can be achieved	Depending on how much is invested, accuracies of down to ±0.05 mm and better can be achieved	Accuracies of down to ±0.1 mm are possible without load reversals
Rigidity	Very good values can be achieved thanks to intermediate mechanical elements	Good because oil can hardly be compressed at all	Poor because air is compressible
Forces	Not overload-proof, poor degree of efficiency due to downstream mechanical elements, very high forces can be achieved	Overload-proof, very high forces can be generated with high system pressures of up to 600 bar (F ‹ 3000 kN)	Overload-proof, force limited by compressed air and cylinder diameter (F ‹ 30 kN to 6 bar)

Reference: Festo Didactic SE, 08/2013, *Basic Principles of hydraulics and electro-hydraulics*

U.S. Fluid Power Industry Brief

Key conclusions include:

•In 2020, the manufacture of fluid power components was an $18.2 billion industry in the United States. It was also competitive worldwide, with 2020 exports valued at $5.6 billion.

•It is estimated that 744 companies in the United States employ more than 64,000 people in the manufacture of fluid power components, representing an annual payroll of more than $4.4 billion.

•Fluid power has a major downstream economic impact. It is estimated that the top industries that depend on fluid power represent thousands of companies in the United States, employing more than 845,000 people for an annual payroll of more than $60 billion.

•Fluid power and the industries it serves depend on a highly educated workforce, leading to investment in new fluid power education and training resources. More middle schools, high schools, technical colleges and universities are teaching fluid power than ever before.

•Fluid power technology continues to advance to better meet the needs of its diverse customer base. Product development is supported by a growing research community that helps to bring new technologies to the marketplace.

Case Study

In a small group (4 to 5), explore a fluid power application.

Chose a case study from https://web.nfpa.com/fluidpower/applications.aspx
(let's not duplicate!)

Electrohydraulics*	Electropneumatics*	Pneumatics Automation at Work*
Anti-stall control for hydrostatic drive	Multiple welding machine	Assembly
Concrete saw	Paint spray system	Broaching
Airframe tester	Pneumatic torquer for engine bolts	Clamping
Missile pump test	Well-digger brake	Drilling
Hitch control for a tractor	Stapler test	Facing
Plastic injection molding	Tension control of a paper web	Loading
Jackknife carloader	Component inserter	
Flying cutoff shear		
Flight simulator		
Rough terrain forklift		

Or: https://web.nfpa.com/fluidpower/pneumatics-casestudies.aspx

Study your application and present to the class:
- summary of application
- key features of the use of fluid power
- advantages of using fluid power

Chapter Reading

Chapter 1

All