

Hydraulics

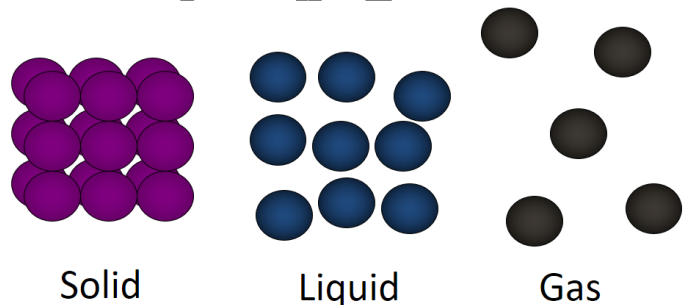


Hydraulics is the study of fluid motion and its applications.

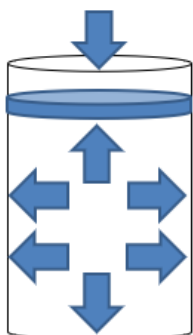
What is hydraulics?

Hydraulics is the study of fluid motion and its applications. A **fluid** is a liquid or a gas that flows. Recall that there are three major states of matter: solid, liquid, and gas. Two additional states are plasma and Bose-Einstein condensates, but they are less common in our daily lives. Plasmas are uncommon on Earth and Bose-Einstein condensates were created by humans.

In solids, molecules are tightly packed together and don't move around much. As such, solids retain their shape and do not flow. In liquids, molecules are close together, but not packed. Liquids have a fixed volume, but do not have a fixed shape. Rather, they take on the shape of their container. In gases, molecules are spread out and move around freely. Gases have no fixed volume and no fixed shape. Instead, they take on the shape and volume of their container. As mentioned previously, both liquids and gases, not having packed molecules, can flow. Some fluids (mainly liquids, but few gasses) are **incompressible**, meaning they cannot be mashed together into smaller spaces. Most liquids are essentially incompressible because their molecules are already very close together. It is this property of fluids that is used in hydraulic applications.



The three major phases of matter are solid, liquid, and gas.



Pressure in a liquid is transmitted equally throughout.

Pascal's Law

The main principle of hydraulics is **Pascal's Law**, developed by French scientist Blaise Pascal in the mid-1600s. Pascal's Law states that pressure in a liquid is transmitted equally throughout the liquid. This means that in a closed system, any force exerted on a point in a liquid is felt at all points within the liquid. Pressure is calculated as $P = \frac{F}{A}$, where F is force, and A is the cross-sectional area over which the force is applied. Pascal's Law depends upon the incompressibility of liquids. So, how does this translate to hydraulic applications?

Applications of hydraulics

Think about an open water bottle filled with water. If you squeeze that bottle, what happens? Because the water is incompressible, it doesn't just bunch together more within

the bottle; instead, it squirts out the top. This is a simple example of Pascal's Law in practice. We are surrounded by more complex examples. From brakes in our cars to heavy construction machinery, hydraulics applications are ubiquitous.

Within a hydraulic system, an initial **effort force** puts pressure on a liquid over a given area. This pressure is transmitted throughout the liquid, reaching a second area (in some systems, a third or a fourth, too), in which it exerts a **load force**. If the second area is larger than the first, the force is multiplied such that the load force exceeds the effort force, though it acts over a shorter distance. There are five elements common to most hydraulic systems:



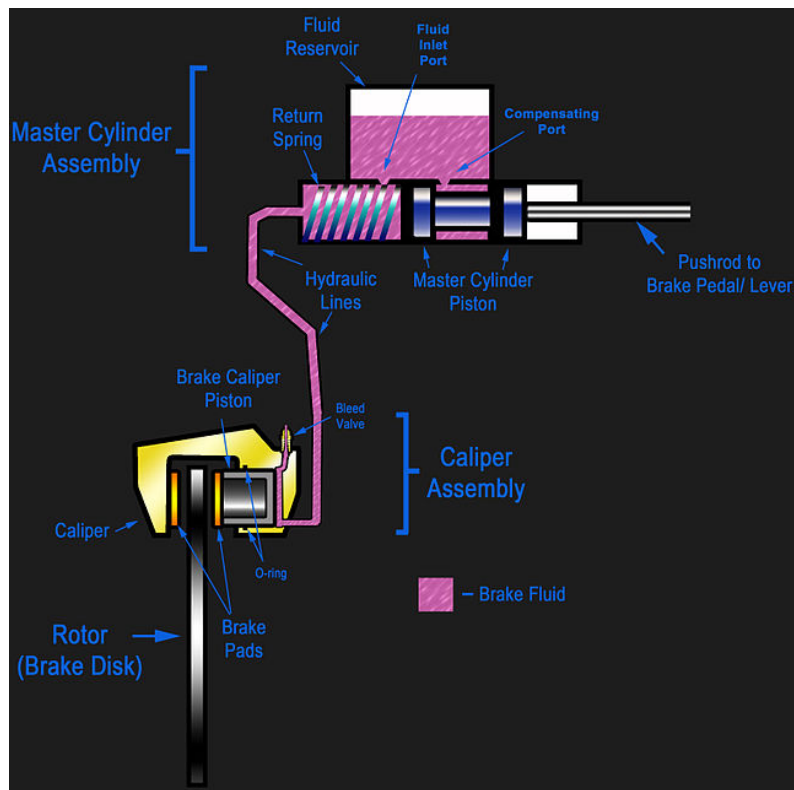
If you squeeze a water bottle, the water squirts out.

Ecobottle Sample



This section has been removed

Hydraulics are used within automobiles as well, in the form of **brakes**. The relatively small effort force you exert when pressing down on the brake pedal is translated into a great enough load force to stop the vehicle. There is a small piston (the master cylinder) at the pedal end and larger pistons adjacent to the brake discs or brake drums on each of the four wheels (or on the two rear wheels, depending on the vehicle). When you depress the pedal, the brake fluid in the small piston is pushed, exerting a force on the brake pads at the other end, which contact the brake discs to slow and/or stop the car.



Automobile brakes use hydraulics.

Heavy machinery such as **log splitters** also make use of Pascal's Law and the power of hydraulics. Log splitters have a two-stage hydraulic oil pump. One stage works with high pressure and low volume, meaning that less oil is pumped into the cylinder, but it is at high pressure. The piston is punched into the log in this stage because great force is required to split a log. In the second stage, the oil is at a lower pressure, but there is a higher volume, so that the piston can be pulled out of the log quickly. Less force is required in this stage.



Some log splitters use hydraulics.

The hydraulic pump of a log splitter is usually powered by a gas engine.

Excavators used to move large masses of dirt similarly rely on hydraulics. Hydraulics control both the arm and the cab of an excavator. Within the cab, the driver uses controls to send electrical signals to valves adjacent to the hydraulic pumps. Small hydraulic lines branch out from the valves and connect to pistons on the arm. These pistons work to extend and shorten, rotate, and lift and lower the arm, depending on the line through which the oil is pumped and thus the direction it is pushed. The pistons act as the excavator's muscles, helping it to move its arm



Excavators rely on hydraulics.

much like a human appendage. The cab is controlled by a separate system that causes it to rotate.



Loaders often have three pairs of pistons.

Loaders generally have three pairs of pistons, each performing a different task. One pair is used to lift and lower the bucket of the loader. A second pair rotates the bucket to dump a load. The third pair opens the bucket for use in grabbing and picking up large objects.

Dump trucks often have hydraulic-powered telescoping cylinders to lift and lower the bed.

Additional applications include aircraft landing gears, brake systems, and flaps; missiles; automobile transmissions and steering; trash compactors; and elevators.

Advantages of hydraulics

Ecobottle Sample

TWFF

This section has been removed



Reading Comprehension Questions:

1. What
2. What is a fluid?
3. What is
4. What is meant by the term “incompressible”? What makes liquids incompressible?
5. What is Pascal’s Law?
6. Describe
7. What are
8. Explain how a hydraulic jack works.
9. Why is
10. How do the pistons in an excavator act like muscles?
11. List

Extension Questions:

12. What is another simple example of hydraulics in practice aside from water bottles?
13. Research
14. Choose an

Ecobottle Sample



This section has been removed

TWF SAMPLE

References

- Bagley, M. (2016). "Matter: Definition & the Five States of Matter." *LiveScience*. Retrieved 29 Dec 2017 from <https://www.livescience.com/46506-states-of-matter.html>.
- BBC (2014). "Hydraulics." *Science*. Retrieved 28 Dec 2017 from http://www.bbc.co.uk/schools/gcsebitesize/science/triple_aqa/using_physics_make_things_work/hydraulics/revision/1/.
- Brain, M. (2000). "How Hydraulic Machines Work." *HowStuffWorks.com*. Retrieved 28 Dec 2017 from <https://science.howstuffworks.com/transport/engines-equipment/hydraulic.htm>.
- Hodanbosi, C. (1996). "Pascal's Principle and Hydraulics." *National Aeronautics and Space Administration*. Retrieved 28 Dec 2017 from https://www.grc.nasa.gov/www/k-12/WindTunnel/Activities/Pascals_principle.html.
- Lee, K. (2017). "Uses of Hydraulic Systems." *Sciencing*. Retrieved 28 Dec 2017 from <https://sciencing.com/uses-hydraulic-systems-5478901.html>.
- "Piston". (n.d.) *Merriam-Webster*. Retrieved 29 Dec 2017 from <https://www.merriam-webster.com/dictionary/piston>.
- Prausnitz, JM, Poling, BE, Rowlinson, JS. (2000). "Liquid." *State of Matter*. Retrieved 29 Dec 2017 from <https://www.britannica.com/science/liquid-state-of-matter>.
- The Editors of Encyclopædia Britannica. (1998). "Fluid." *Physics*. Retrieved 29 Dec 2017 from <https://www.britannica.com/science/fluid-physics>.
- The Editors of Encyclopædia Britannica. (1998). "Hydraulics." *Fluid Mechanics*. Retrieved 28 Dec 2017 from <https://www.britannica.com/science/hydraulics>.
- Woodford, C. (2017). "Brakes." *Explain That Stuff*. Retrieved 29 Dec 2017 from <http://www.explainthatstuff.com/brakes.html>.
- Woodford, C. (2017). "Hydraulics." *Explain That Stuff*. Retrieved 28 Dec 2017 from <http://www.explainthatstuff.com/hydraulics.html>.