

FLUIDS

Read the text below and answer the questions below.

A fluid is any liquid or gas or generally any material that cannot sustain a tangential, or shearing, force when at rest and that undergoes a continuous change in shape when subjected to such a stress. This continuous and irrecoverable change of position of one part of the material relative to another part when under shear stress constitutes flow, a characteristic property of fluids. In contrast, the shearing forces within an elastic solid, held in a twisted or flexed position, are maintained; the solid undergoes no flow and can spring back to its original shape. Compressed fluids can spring back to their original shape, too, but while compression is maintained, the forces within the fluid and between the fluid and the container are not shear forces. The fluid exerts an outward pressure, called hydrostatic pressure, that is everywhere perpendicular to the surfaces of the container.

- 1- What is a fluid?
- 2- What is flow?
- 3- What is hydrostatic pressure?

FLUID POWER

Read the text below and complete the gaps with words from the box.

INTRODUCTION

Fluid power is the use of fluids under **pressure** to generate, control, and transmit power. Fluid power is subdivided into **hydraulics** using a liquid such as mineral oil or water, and **pneumatics** using a gas such as air or other gases.

Compressed-air and water-pressure **systems** were once used to transmit power from a central source to industrial users over extended geographic areas; fluid power systems **today** are usually within a single building or mobile machine.

Fluid power systems perform work by a pressurized fluid bearing directly on a piston in a **cylinder** or in a fluid motor. A fluid cylinder produces a force resulting

in linear motion, **whereas** a fluid motor produces torque resulting in rotary motion. Within a fluid power system, cylinders and motors (also called **actuators**) do the desired work. Control components such as **valves** regulate the system.

today	pressure	whereas	actuators	valves
hydraulics	cylinder	systems	pneumatics	

<https://www.britannica.com/science/hydraulic-power>

Hydraulics

Introduction

The study of the forces and motions encountered in liquids, such as water or oils, is known as hydraulics. It is part of the larger field of fluid mechanics, which includes gas flows and aerodynamics. Hydraulics is used to design piping systems, pumps, propellers, water turbines, hydraulic presses, and flow-measuring devices **1.It is subdivided into hydrostatics, the study of forces encountered in liquids at rest, and hydrodynamics, the study of liquids in motion.** Hydraulics is applicable to essentially incompressible fluids, fluids that do not contract under pressure, and low-speed air flow.

Hydrostatics

The French mathematician Blaise Pascal stated that the pressure at any point at the same elevation in a confined liquid is the same. Since pressure is force per unit area, the total force exerted on a body containing a fluid is proportional to the surface area exposed to the fluid. This forms the principle of the hydraulic press. Leakproof pistons are fitted in two arms of a U-shaped vessel with different cross sections, and the pressure on both pistons remains the same. If the area of

the large piston is 50 times that of the small piston, the total force on the large piston is 50 times that on the small one. The work done (force \times distance), however, remains the same in the absence of friction. Thus, the small piston must be pushed down 50 times farther than the large piston rises. 2. **This force amplification is used in hydraulic jacks to lift automobiles and building slabs and in hydraulic presses for forging and to form car-body components and airplane sections.**

Archimedes discovered in the 3rd century BC that a body immersed in liquid experiences an upward buoyant force equal to the weight of the fluid displaced, and a floating body displaces its own weight in the liquid. 3. **Accordingly, a ship weighing 10,000 tons will float at a depth where it displaces the same weight in water.** Pressure increases with depth due to the weight of the liquid. The increase in pressure is proportional to the density of the fluid times the height of the liquid column. This principle is applied in manometers, which are used to measure the pressure of water flowing in a pipe at above atmospheric pressure. One leg of a U-tube, filled with mercury at the bottom, is connected to the pipe. 4. **The other leg is open to the atmosphere.** The water pushes the mercury up the open leg, and the water pressure in the pipe is related to the difference in the height of the mercury in the U-tube.

Hydrodynamics

The principle of continuity in hydrodynamics is based on the assumption that liquid flowing steadily through a contracting pipe has a constant volume flow rate at any cross section. 5. **The volume flow rate at each interval is equal to the velocity of the liquid times the cross-sectional area.** Since the cross-sectional area decreases as the pipe narrows, the velocity must increase.

For an incompressible ideal, or frictionless, liquid, the total mechanical energy in the flow of liquid through any contracting pipe is preserved according to Daniel Bernoulli's principle, proposed in 1738. 6. **According to this principle, the total**

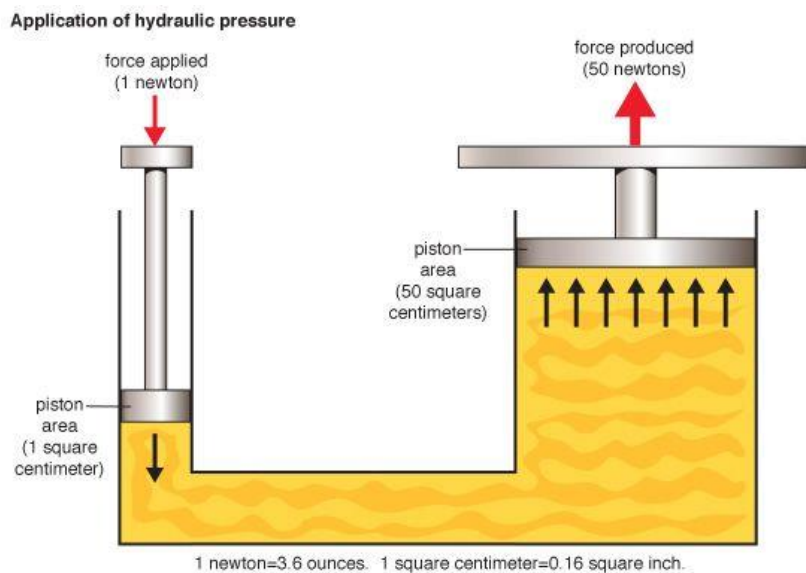
mechanical energy at any cross section through the pipe is the same. Bernoulli's principle is represented by the following equation:

Here ρ = density, P = pressure, V = velocity, g = acceleration due to gravity, and Z = elevation above an arbitrary horizontal line.

The Torricelli theorem, proposed by Italian mathematician Evangelista Torricelli in 1644, is based on Bernoulli's principle. It enables the prediction of the flow velocity through a small nozzle at the bottom of a large open tank. Since the pressure is atmospheric at both the tank top and at the nozzle, the difference in potential energy from the top of the liquid to the nozzle is converted to kinetic energy. Assuming that the velocity at the top is essentially zero, Bernoulli's equation can be used to estimate the velocity of the fluid leaving the tank with Torricelli's equation:

$$V = \sqrt{2gH}$$

In this equation V is the velocity of the liquid flowing out the nozzle, g is the acceleration due to gravity, and H is the distance between the liquid surface and the center of the nozzle.



7.Both the Bernoulli equation and the Torricelli equation apply only to the steady flow of frictionless, incompressible fluids. They must be adjusted for high-speed gas flows, unsteady flows, and for friction, which is encountered in all real applications.

Although the need to modify these equations was known by the late 18th century, no solutions were available. Different corrections seemed applicable for slow-flowing oils and water flowing at normal velocities. The explanation was found by Osborne Reynolds in 1883. **8.He showed that if dye was carefully injected into a low-speed flow of liquid in a pipe, it did not disperse but stayed in layers.** This is called laminar flow. As the flow velocity in the pipe was increased, however, the dye stream broke up into eddies. Reynolds found that this turbulent flow was related to the fluid's viscosity, a liquid property proportional to the force required to shear it. Turbulent flow occurs when the ratio of the velocity, diameter, and density to the viscosity, now called the Reynolds number, exceeds about 2,500. The flow always remains laminar below a Reynolds number of 2,100.

Reynold's experiment led to an understanding of the different behaviors of laminar and turbulent flows over surfaces such as wings and ship hulls and in channels. **9.It also laid the groundwork for modern hydraulics and fluid dynamics.** Another major advance was made by Ludwig Prandtl, who in 1904 suggested that the viscous (friction) effects on a streamlined body are limited to a thin boundary layer along the body surface. This discovery led to developments in aerodynamics and forms the basis for many advances in fluid machinery.

Piping Systems, Dams, and Canals

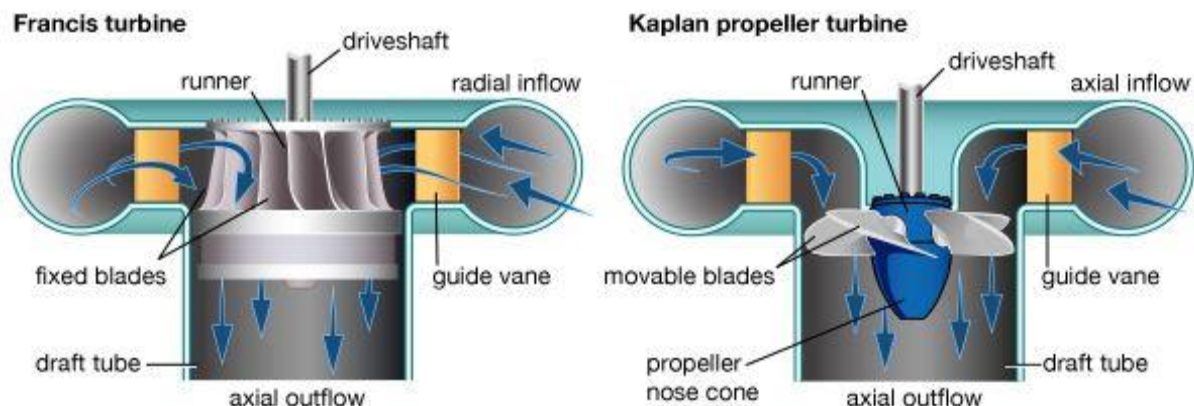
Hydraulics enters in the design and construction of municipal water systems. Water is taken from a lake or river and pumped, after treatment, through a distribution system to the users. The system is laid out to ensure that customers

far away are not deprived of water if there is heavy use closer to the pumping station.

The construction of dams for flood control and power generation is also a task for the hydraulic engineer.¹⁰ **Since water pressure increases with the depth of the water, the dam must be thicker at the bottom than at the top.** Other hydraulic applications involve the design of sewer and irrigation systems and of ship canals and locks.

Hydraulic Machinery

Pumps, propellers, and turbines are examples of hydraulic machinery. In a centrifugal pump an impeller imparts tangential velocity to the fluid through vanes that are driven by an external power source. ¹¹**The vanes increase the kinetic energy, and sometimes the pressure, of the flow.** The high-speed flow leaving the impeller is then slowed through a set of diffusing passages where the kinetic energy is converted to flow energy and the outflow pressure increases. In ship propellers the difference in pressure between the forward and backward side of the blades creates thrust, which propels the vessel.



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Waterwheels date from Roman times when water flowing past a rotating paddle wheel was used to produce power for milling. These waterwheels, however,

extracted only a small portion of the energy in a stream. **12. Modern hydraulic power-producing machines, known as turbines, work on different principles.** Their design depends on the height between the reservoir and the turbine outflow. For a large height difference, or head, and low flow rates, the Pelton wheel or turbine is used. Here the water flowing down a pipe, or penstock, accelerates through a nozzle at the bottom. The high-speed water is then directed onto a wheel. Pelton turbines are typically used if the head is greater than about 500 feet (150 meters). **13. For smaller heads the Francis turbine is commonly used. It is the counterpart of a centrifugal pump.** Water flows into the turbine in a radial direction and is discharged at lower pressure nearly axially downward. For low heads and high flow rates, vertically installed propeller or Kaplan turbines are used. Whereas in ship propellers the turning propeller moves the water, propeller turbines use flowing water to turn the propeller. Another hydraulic machine, the torque converter of an automobile, permits smooth transmission of power from the engine to the drive shaft.

14. Fluid forces transmitted in a pipe have many applications. The hydraulic brake in a car depends on the pressure exerted on a fluid reservoir by the brake pedal. This force is then transmitted through oil lines to move the brake shoes. Power steering uses a hydraulic system to magnify the torque applied to the steering wheel to turn the car. Hydraulic power is also used in airplanes to move control surfaces, such as the tail and rudder.

Fred Landis