Video z03 (2:35)

Fluids

Name: _____

fluid: a material w/the ability to flow and change shape

Video z06 (5:14)

(mass) density, ρ =

Equation:

For a particular object:

For a particular fluid:

	Gases	Liquids
Particle spacing		
Fixed shape?		
Fixed volume?		
Compressible?		

-- Unless we say otherwise, when we say "density," we mean "mass density."

-- In SI, the unit for density is…

-- In proper SI units, the density of water is…

Liquids and solids have "fixed" densities; gases don't.

A substance's specific gravity (γ) is a unitless number that compares the density of that substance relative to the density of…

Equation:

$\gamma_{\text{fresh water}}$ $\gamma_{\text{iron or steel}}$ γ_{aluminum}

$\gamma_{\text{salt water}}$ γ_{mercury} γ_{ethanol}

EX. Given the specific gravities of steel and ethanol above, determine the densities of these materials, using the proper SI units.

Video z09 (4:12)

pressure: Equation:

SI unit for pressure:

At sea level, air pressure is about…

Video z12 (8:36)

Pressure in Fluids

Fluid pressure _____ with depth because…

-- For gases in the atmosphere, pressure is greatest at…

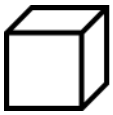
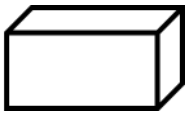
→

→

-- For liquids, the pressure-depth relationship is linear because liquids are…

→

EX. Determine the pressure on the bottom surface of each tank, due to the water.

1 m x 1 m x 1 m   2 m x 1 m x 1 m

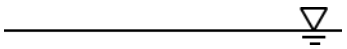
**

Gauge pressure equation:

Video z15 (6:26)

P does NOT depend on total volume of liquid, only type of liquid, gravity, and depth.

The P in the equation $P = \rho g h$ (i.e., the gauge pressure) does NOT account for the pressure AT the liquid's surface (from gases above it). To find the total pressure (P_{tot}) at a given depth, simply add the surface pressure (P_o) to the gauge pressure at that depth.

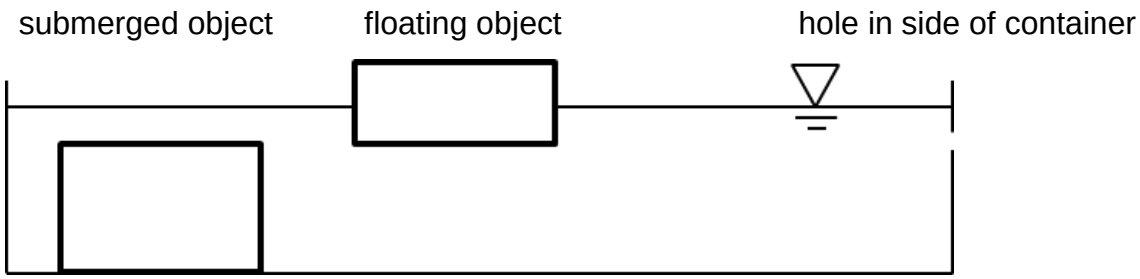


Total pressure equation:

EX. Given that the specific gravity of gasoline is 0.68, find both the gauge AND total pressures 1.4 m below the surface of a tank of gasoline that has air space at the top. Assume the air pressure to be 101.3 kPa.

EX. Repeat the calcs for a depth of 2.8 m in gasoline.

Video z18 (6:23)



In a fluid, the pressure at a given depth is exerted…

→ And pressure always acts _____ to any surface.

Video z21 (4:29)

Fluids flow away from points of _____ P toward points of _____ P (even though there might be quirky things happening ^{w}/P in btwn these pts; more on this later).

Video z24 (9:13)

<u>bouyant force</u>, F_B:

sunken object

-- F_B is the result of the difference in…

floating object

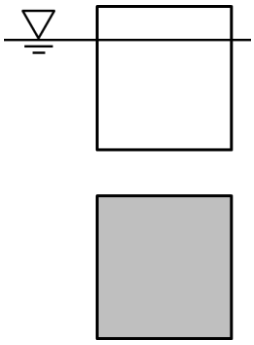
-- Pressures on the sides of the object…

-- The F_B on a <u>completely</u> submerged object is NOT affected by…

-- F_B IS affected by…

Video z27 (5:22)

Because of buoyancy, the net force on an immersed object is always the object's weight.



This net force we call the <u>apparent weight</u> (F_{app}). Equation:

Objects that are floating: weight buoyant force

Objects that aren't: weight buoyant force

EX. A 43 kg rowboat is loaded with 185 kg worth of fishers and fishing equipment. What is the buoyant force on the boat when it is out on the lake?

EX. A 28.4 g lead sinker used by a fisherman has an apparent weight of 0.254 N in water. Find the buoyant force on the sinker.

Video z30 (7:40)

Archimedes' Principle Any object in a fluid experiences an upward buoyant force equal to the weight of the fluid that the object displaces.

-- For a floating object:

→ the displaced fluid's weight the object's weight

→ the displaced fluid's volume the object's volume

floating object

Handy equation for floating objects:

-- For a sunken object:

→ the displaced fluid's weight the object's weight

→ the displaced fluid's volume the object's volume

sunken object

**

Equation for buoyant force:

From density, we see that… $m_{df} = \rho_f V_{disp}$, and so…

** It is the _____ of the immersed object, NOT its _____, that affects the buoyant force.

A life preserver greatly increases "your" _____ but barely increases "your" _____.

Video z36 (3:59)

A floating tree trunk has specific gravity 0.41 and a volume of 0.79 m^3. Find the log's apparent weight, the buoyant force on it, and the volume of water it displaces.

Video z39 (3:41)

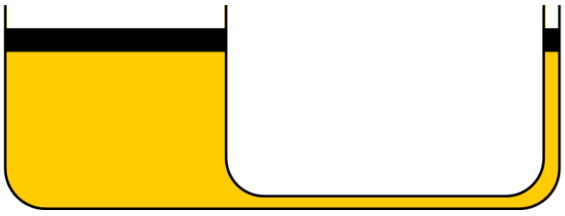
A solid copper cube – 0.112 m on a side – is under water. Its apparent weight is 109.16 N. Find copper's specific gravity.

Video z42 (4:57)

Pascal's Principle External pressure applied to a confined fluid is transmitted equally to every point in the fluid.

e.g.,

A <u>hydraulic lift</u> has two pistons, one that is much larger in surface area than the other.



Equation:

The effect of a hydraulic lift is that we get to input a small force and transform it into a larger one, but the price we pay is that…

** In physics, this is analogous to the behavior exhibited by…

Video z45 (3:06)

A hydraulic lift's pistons have areas of $0.0254\ m^2$ and $1.33\ m^2$. What minimum force is needed for us to elevate a 1420 kg car with the aid of the hydraulic lift?

EX. For the problem above, find the pressure on each piston.

Video z48 (2:10)

Fluids in Motion

flow rate:

-- units could be either OR

Video z51 (3:40)

Two Types of Fluid Flow

laminar flow: each fluid "particle" perfectly follows the particle just ahead of itself along a smooth trajectory called a streamline

model profile of laminar flow in a pipe

--

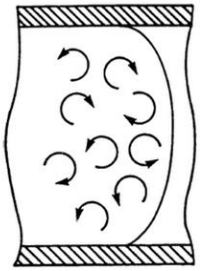
--

turbulent flow:

--

-- eddies (or vortices) are clear indicators of turbulent flow

--



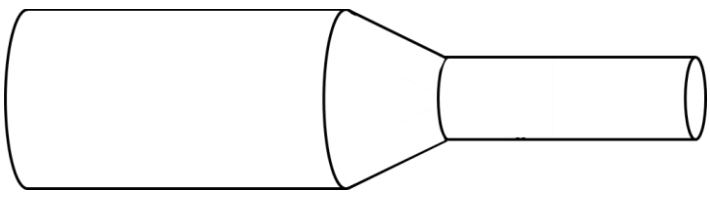
Video z54 (6:18)

Principles of Fluid Flow

For a fluid confined in a pipe:

FLOW RATE AT "EARLIER" POINT

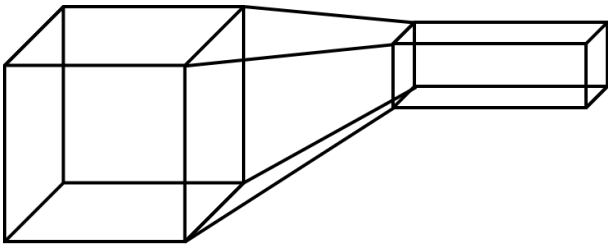
FLOW RATE AT "LATER" POINT



Using volumes…

The units here would be…

An equivalent expression, then, which deals with the cross-sectional areas of two different points along the pipe – and the speeds of the fluids through those cross-sections – is called the <u>continuity equation</u>:



What are the units here?

Conceptual examples: --

--

Video z57 (2:26)

In a water-treatment plant, water flows at 0.86 m/s through a 0.64 m diameter pipe. Find the water's speed when this flow narrows into a pipe of diameter 0.28 m.

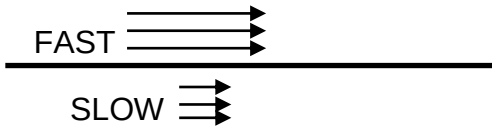
Video z60 (6:56)

Bernoulli's Principle

For a fluid traveling // to a surface:

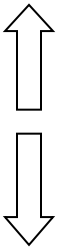
-- FAST-moving fluids exert _____ pressure.

-- SLOW-moving fluids exert _____ pressure.



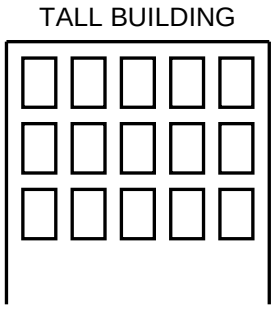
EX. airplane wing / helicopter propeller

Resulting Forces

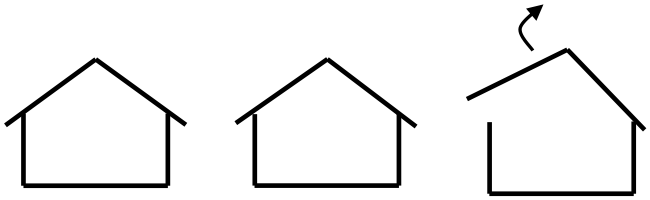


EX. frisbee

EX. windows and high winds (e.g., tornadoes)



EX. roof in a windstorm

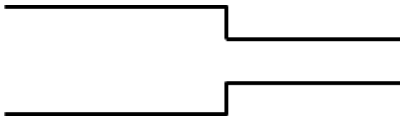


Video z63 (5:59)

Bernoulli's principle can be rationalized in two ways:

1. Newton's 2nd law

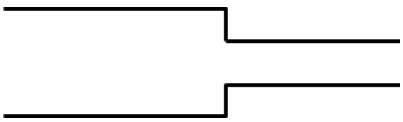
a level pipe of varying diameter



_____ speed _____ speed

_____ pressure _____pressure

2. conservation of "energy"



For each pipe section, the sum of the following is a constant:

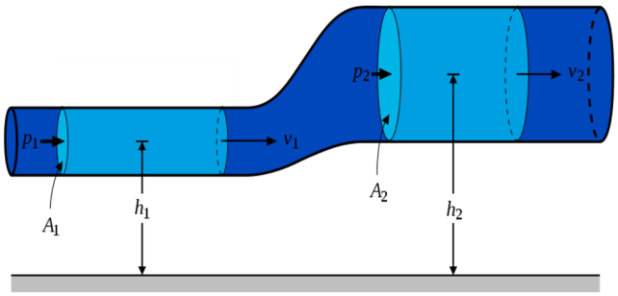
-- "KE" from fluid's motion

-- PE_g due to elevation of fluid

-- PE due to fluid's pressure

Video z66 (6:26)

The conservation of energy idea brings us nicely to the Bernoulli Equation (which IS the conservation of energy, but with units of pascals instead of _____).



EX. A level pipe carries water under pressure. At one point, the water's speed is 0.48 m/s and its pressure is 24,500 Pa. In an adjacent section, the pipe is constricted; the water's speed increases to 3.27 m/s. Find the pressure in the adjacent section.

Video z69 (5:38)

A pipe carries water under pressure in a factory. At one point, the speed is 2.46 m/s and the pressure is 31,500 Pa. In an adjacent section, the pipe is 1.75 m lower; there, the pressure is 26,700 Pa. Find the speed in the adjacent section.