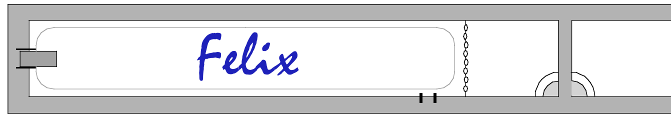
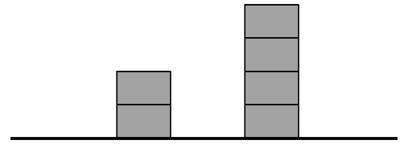
PhyzSpringboard: Pressure

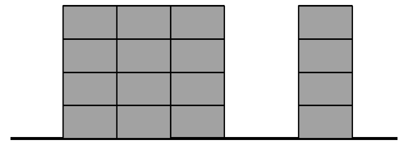


PRESSURE AND WEIGHT



1.a. Which is heavier: __the short stack or _x_the tall stack?

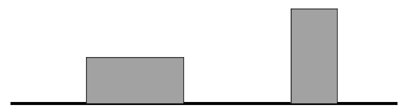
b. Where is the pressure greater: _x_under the short stack or __under the tall stack?



2.a. Which is heavier: _x_the wide stack or __the narrow stack?

b. Where is the pressure greater: __under the narrow stack or __under the wide stack?

No: same pressure for both!



3.a. In which configuration is the brick heavier: __lying down or __standing up?

No: same weight for both!

b. When is there greater pressure under the brick: __when it's lying down or _x_when it's standing up?

4.a. What's the difference between weight and pressure?

Weight is gravitational force
Pressure is how the force is distributed across an area.

b. Reconsider the short and tall stacks in question 1. How could you make the *pressures* under those stacks equal (without changing their respective weights)?

Take the top two bricks off the tall stack and set them to the side of the bottom two bricks.

PRESSURE

5. What's the definition of pressure? What units are used to express pressure?

Pressure is the quotient of force and area: $P = F/A$ (measured in $N/m^2 = Pa$)

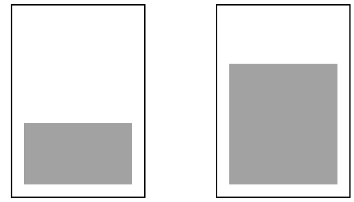
6. Why is it that 120-lb. Stiletto Stella can crack ceramic tiles with her high heels while 220-lb. Snowshoe Shawn can walk on a snow drift without sinking in?

Stella's Stilettos concentrate a great deal of force in the small area of the heal.
Sam's snowshoes distribute his weight across a large area.

7. Can you offer any safety tips to thin-ice and quicksand rescuers?

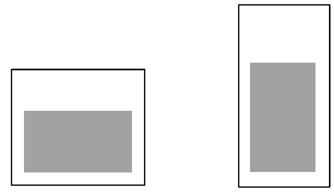
Lie down to distribute weight across a wide area and thus keep pressure low.

LIQUIDS



8. a. Which volume of water is heavier: ___100 mL or _x_200 mL?

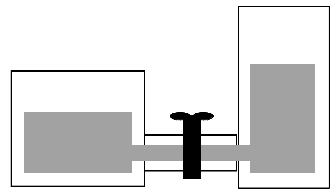
b. Where is there more pressure: ___at the bottom of the 100 mL or _x_at the bottom of the 200 mL?



9. a. Which is heavier: ___the wide 100 mL or ___the tall 100 mL?

No: same weight for both!

b. Where is the pressure greater: ___at the bottom of the wide 100 mL or _x_the bottom of the tall 100 mL?



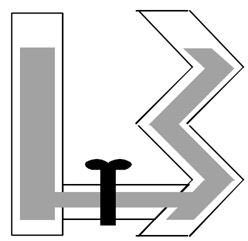
10. Suppose a pipe and valve assembly were arranged to connect the bottom of the wide container to the bottom of the tall container. If the valve were opened,

a. which way—if either—would the water flow?

From tall to wide.

b. When would the flow described above stop?

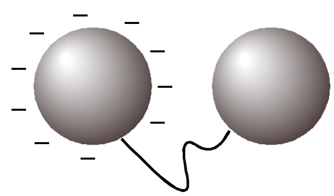
When the water levels were equal: same pressure



11. Consider the straight cylinder and the crooked cylinder. Suppose it takes 100 mL to fill the straight cylinder to a height of 10 cm. And suppose it takes 300 mL to fill the crooked cylinder to the same height. If a valve were opened connecting the bottoms of these cylinders, which way—if either—would the water flow?

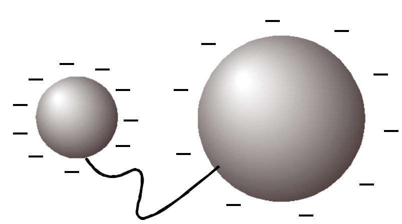
No flow: pressures are equal

RANDOM ELECTROSTATIC CHARGE QUESTIONS



12. Consider to conducting spheres with equal radii. One is charged and the other is neutral. If a conducting wire connected the two spheres, what—if anything—would happen and when would it stop?

Charge would flow until both spheres had the same charge



13. Consider two conducting spheres, one with twice the radius of the other. Both carry an equal charge. If a conducting wire connected the two spheres, what—if anything—would happen and when would it stop?

Charge would flow until both spheres had the same charge DENSITY (and thus, the same VOLTAGE).

GAUGE PRESSURE

If you want to know the air pressure in your tires, you might use a pressure gauge.

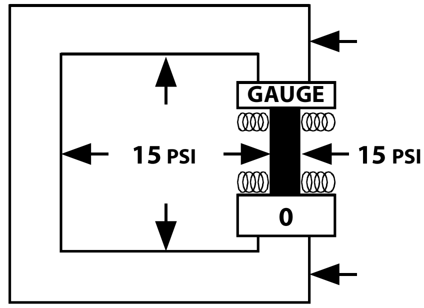
If the pressure gauge were used to measure the air pressure in a flat tire, it would indicate 0. Zero pascals, zero PSI, zero atm, zero mm-Hg, zero torr, etc.

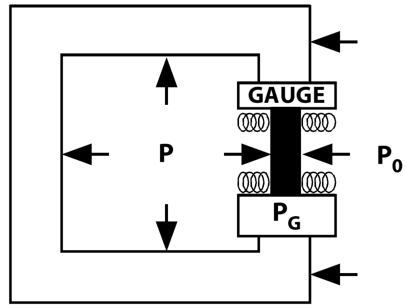
But the true (or absolute) pressure in the flat tire is equal to atmospheric pressure. The pressure gauge indicates how much the pressure inside the container exceeds atmospheric pressure.

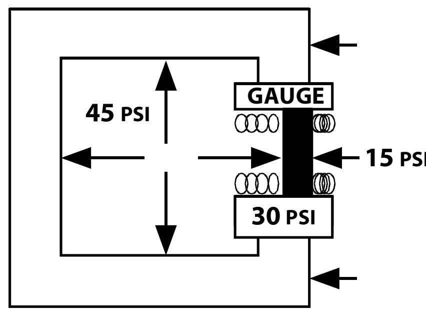
So gauge pressure is the difference between absolute pressure and atmospheric pressure.

$P_G = P - P_0$

If the tire were filled to a gauge pressure of 30 PSI (pounds per square inch), the absolute pressure in the tire would be about 45 PSI, since atmospheric pressure is about 15 PSI.







14. Consider a pool. Initially, the pool is empty. Atmospheric pressure is 100,000 kPa. With no water in the pool, the gauge reads 0.

a. What is the absolute pressure at the bottom of the empty pool?

$P = P_0 + P_G$ Since $P_G = 0$,

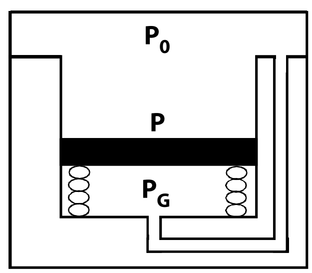
$P = 100{,}000 \text{ kPa} + 0 = 100{,}000 \text{ kPa}$

b. Water is poured into the pool until the gauge reads 1,000 kPa. What is the absolute pressure at the bottom of the container now?

$P = P_0 + P_G$

$P = 100{,}000 \text{ kPa} + 1000 \text{ kPa}$

$P = 101{,}000 \text{ kPa}$



c. Suppose the chamber surrounding the pool were evacuated of atmosphere. Determine P_0, P, and P_G.

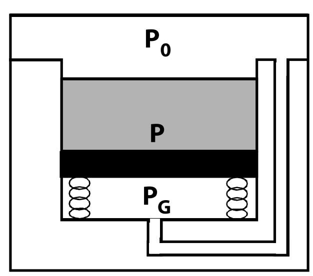
$P_0 = 0$

$P = 1000 \text{ kPa}$

$P_G = P - P_0$

$P_G = 1000 \text{ kPa} - 0$

$P_G = 1000 \text{ kPa}$



PRESSURE AND DEPTH

Pressure is defined as the amount of force acting on each unit of area ("force per area").

$P = F/A$

The pressure that an object exerts on the surface it rests on depends on its weight and the area of its "footprint."

At a given depth in a fluid, the pressure depends on the weight of a certain volume of fluid above it.

15. Consider one square meter at the bottom of a swimming pool which, for some reason, is in an evacuated chamber. If the depth of the water is one meter,

a. What is the mass of that water? (The density of water is 1000 kg/m^3.)

$m = \rho V = 1000\ kg/m^3 \cdot 1\ m^3 = 1000\ kg$

b. what is the weight of the water sitting on that square meter? (Use g = 10 m/s^2.)

$W = mg$

$W = 1000\ kg \cdot 10\ m/s^2 = 10{,}000\ N$

b. What is the pressure of the water one meter below the surface?

$P = F/A$

$P = 10{,}000\ N / 1\ m^3 = 10{,}000\ Pa = 10\ kPa$

c. With no atmospheric pressure, how does the absolute pressure compare to the gauge pressure?

They are equal: $P_G = P$

16. The atmosphere is allowed in until atmospheric pressure is 100,000 kPa.

i. Why does the addition of atmospheric pressure NOT change the gauge pressure?

The gauge measures the difference between absolute pressure and atmospheric pressure.

ii. What is the absolute pressure now?

$P = P_G + P_O$

$P = 10{,}000\ kPa + 100{,}000\ kPa = 110{,}000\ kPa$

17. Write an expression for gauge pressure in terms of fluid density (ρ), gravitational acceleration (g), and depth (d).

$P_G = F/A = mg/A = \rho Vg/A = \rho dAg/A = \rho gd$