Lesson 56: Pressure (AP Only)

Although we don't think about it, we live at the bottom of a roughly 100 km deep "sea" of air.

- Air is made of molecules, so it has mass. Under the effect of gravity, it quite literally weighs down on us every single moment of our lives.
- When we discuss air pressure, what we are really talking about is the amount of force the air exerts on every surface.
  - This pressure is caused by the microscopic collisions between the air molecules and surfaces such as your body.

When we measure pressure in a fluid in hydrostatics, we must assume that the pressure is acting perpendicular to the surface.

- If any part of the force causing the pressure acted in any other direction, there would be a component of the force parallel to the surface.
- This would mean that the surface would exert an equal but opposite force back against the fluid.
- This would cause the fluid to move parallel to the surface, meaning that the fluid is no longer static.

The pressure of any fluid is measured as the force per area according to the following formula...

$$P = \frac{F}{A}$$

P = pressure (N/m^2 or Pa)
F = force (Newtons)
A = area (m^2)

- Notice that the units for pressure can either be N/m^2 or pascals (named after Blaise Pascal).
  - They are exactly the same, so 1 N/m^2 equals 1 pascal.
  - We will often deal with pressures that are quite a bit higher, so be ready to see measurements in kilopascals (kPa).
    - In fact, 1 atmosphere of pressure at sea level is pretty close to 100 kPa. The common conversion is...

      1 atm = 101.3 kPa

Remember, this is an average air pressure at sea level. Changes in weather can cause changes of ±5 kPa on any given day. At higher altitudes, the air pressure drops. Some people in Tibet live at such high altitudes that the air pressure is about 55 kPa.

Even though force is a vector, pressure is a scalar measurement.

- This is because of the way the force always acts perpendicular to the surface.
  - Even if you change the direction the object is facing, the magnitude of the force (and so also the pressure) will stay the same. This is all we care about when we are measuring pressure.

Example 1: A human hand has an area of 105 cm^2. Determine the amount of force it experiences at one atmosphere of pressure.

First, we will convert 105 cm^2 into metres squared. Remember that 1 m = 100 cm...

$$A = 105\,cm^2\left(\frac{1\,m}{100\,cm}\right)^2 = 105\,cm^2\left(\frac{1\,m^2}{10000\,cm^2}\right) = 0.0105\,m^2$$

Now we calculate the force at one atmosphere (101.3 kPa)...

$$P = \frac{F}{A}$$
$$F = PA$$
$$F = 101.3e3(0.0105)$$
$$F = 1.06e3\text{N}$$

Wow, that's an insane amount of force acting on a hand. The reason your hand doesn't suddenly crush inwards is because your hand's interior must be exerting an equal force outwards.