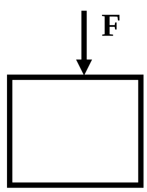
Fluids

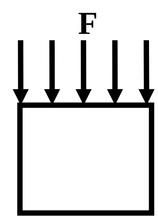
I. Pressure

Concept 1:

In a fluid, the forces are not located at a specific point like a rope pulling on a block. Instead, the forces are distributed across an area of the fluid. For this reason, it is easier to work with force per area instead of force!! This is also true for solid objects like beams or bridges when doing real world problems where forces are distributed across the object.



Single Contact Force



Distributed Force

A. Definition - P

The magnitude of pressure is defined as the force component perpendicular to an infinitesimally small surface area divided by the surface area.

B. An ideal fluid can't resist shear forces. Thus, the force on an ideal fluid must always be perpendicular to its surface or it will no longer be static (not accelerating).

So while pressure has a direction (air pressure in a tire pushes outward on the tire and not inward), we can treat pressure as a scalar similar to how you don't need to use the full power of vectors in doing one-dimensional problems.

C. **Units:**

D. **Conversions:**

1 Atm = **Pa**

1 Atm = **bar**

1 Atm = **torr**

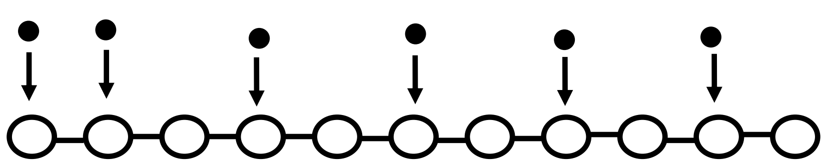
E. Pressure Versus Force

Bed of Nails Magic Trick

A common magic trick is for a person to lie on a bed of nails or to walk across a large amount of crushed glass barefooted. In each case the person is unharmed as if by magic.

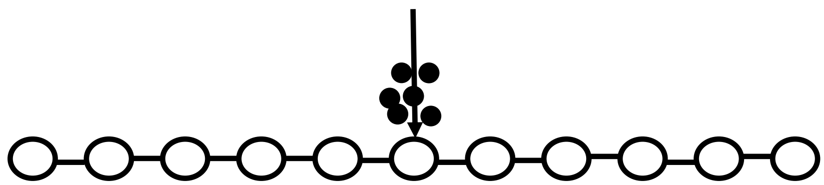
Most people think that a material tears/breaks when too great of a force is applied to the object. Actually the material's response is determined by both by the magnitude of the force and how the force is distributed. **<u>In other words, it is the pressure that is important.</u>**

A layer of atoms in a material are held together by electrical forces between the atoms. A simple model would be a group of kids in a line holding hands as in "Rover-Red-Rover" shown as white circles below. The applied force can be modeled as a group of kids (six kids – black dots shown below) running into the line. Increasing the force would be like increasing the total number of kids running into the line. If the force is spread out (each of the kids runs into the line at a different place – first picture) the line may be able to handle the force.



Low Pressure, Same Force

However, if the kids all run into the line at the same place (second picture) then the same force may break through the line.



High Pressure, Same Force

The secret of not being injured is to have a lot of nails or a lot of small glass pieces to spread out the weight and reduce pressure.

Another common example of this phenomena is floating. When you lay out in the water, you spread out your normal force, this means that each water molecule has to apply less force to support you. However, if you try and walk on water, your normal force is distributed upon a smaller area and the water molecules are unable to apply enough force to offset your weight before they are pushed aside (line breaks).