

Chapter 9 (9.5) – Fluid Pressure

Mechanics is a branch of the physical sciences that is concerned with the **state of rest or motion of bodies that are subjected to the action of forces**

SOLIDS



TAM 210/211: Statics

Rigid Bodies

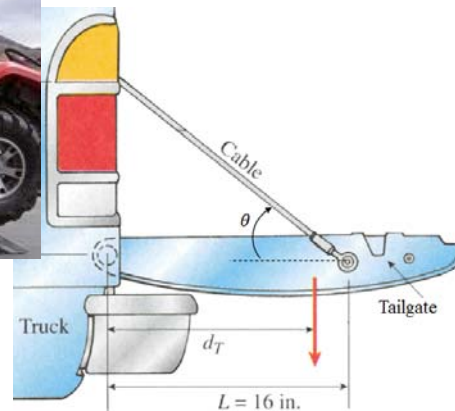


TAM212: Dynamics

Deformable Bodies



TAM 251: Solid Mechanics



FLUIDS



What Makes a Fluid or Solid?



Honey



Rock

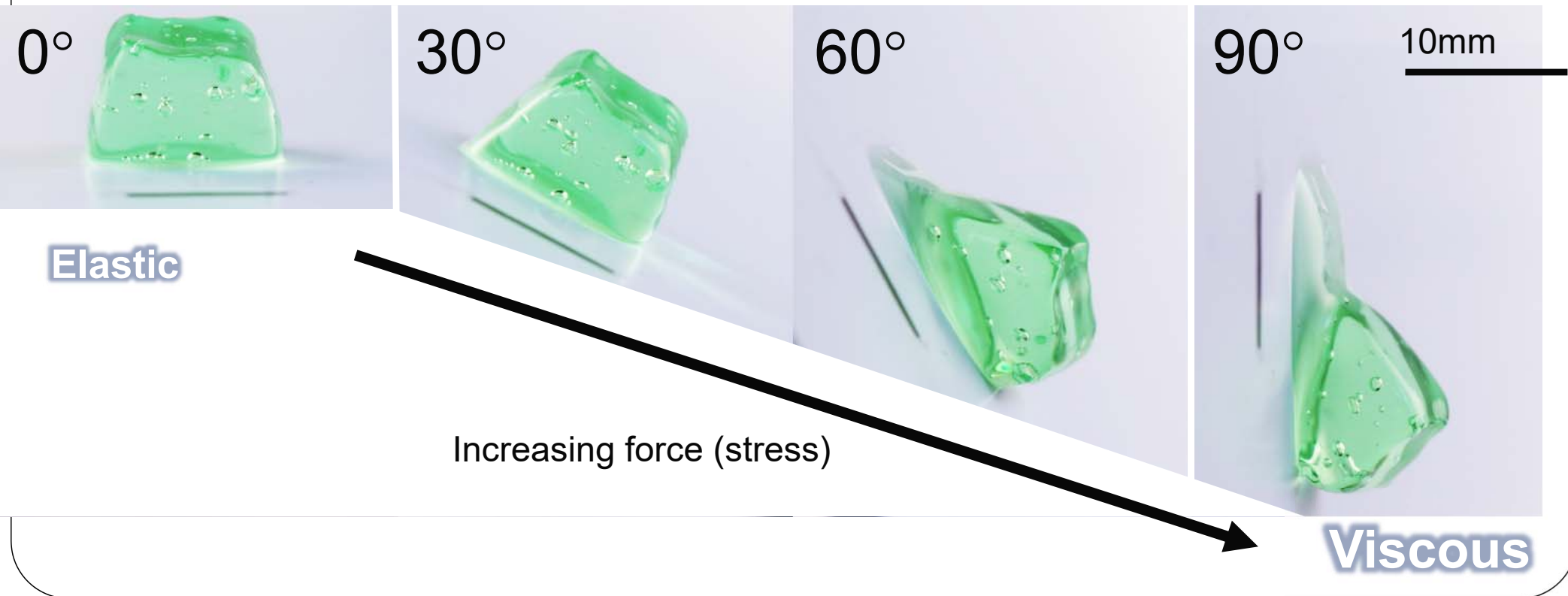
What is Sand?



Particles swollen with water – ‘Squishy Baff’



Aloe Gel



0°

30°

60°

90°

10mm

Elastic

Increasing force (stress)

Viscous

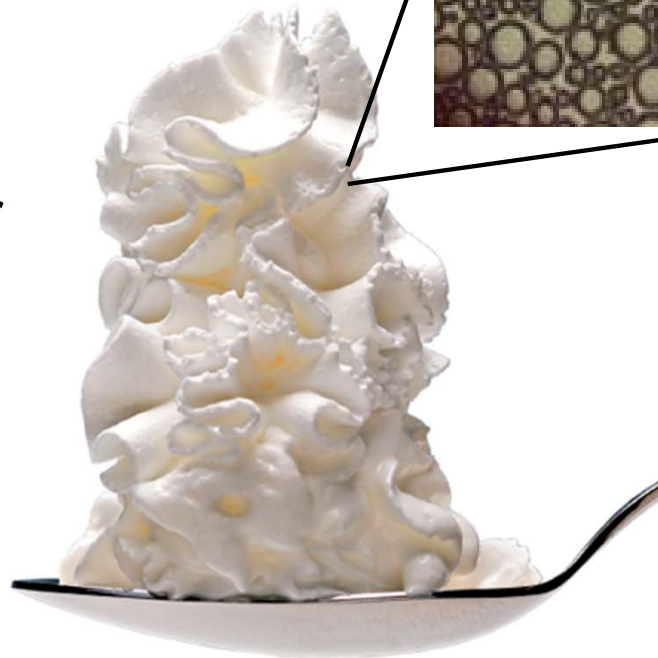
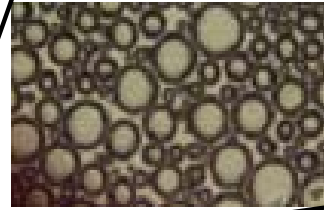
They act like a solid...



But they flow like a fluid once enough stress is applied.

Whipping cream (liquid) + air (gas) = Foam (solid)

with compressed air



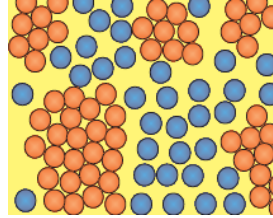
mechanical beating

They look like a fluid...

[Video](#)

cornstarch + water =

(small, hard particles)



But they may bear static loads like solids

Summary

Water takes shape of its container.
Rock does not.



Water and rock fit classical definitions of fluid and rock respectively

Sand and Squishy Baff take the shape of containers, but are composed of solid particles



Sand and Squishy Baff are granular materials which have properties of both fluids and solid

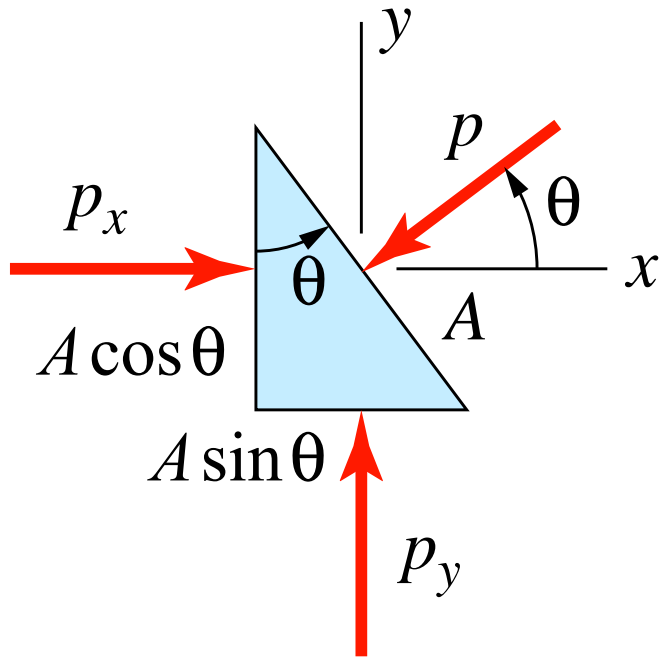
The aloe gel holds its shape and can trap air bubbles until a certain amount of stress is applied.



Aloe gel is a suspension of particles which is able to bear static load like a solid but behaves like a fluid when “enough” stress is applied.

Fluids

Pascal's law: A fluid at rest creates a pressure p at a point that is the *same* in *all* directions



For equilibrium of an infinitesimal element,

$$\Sigma F_x = 0: \quad p_x (A \cos \theta) - p A \cos \theta = 0 \quad \Rightarrow \quad p_x = p,$$

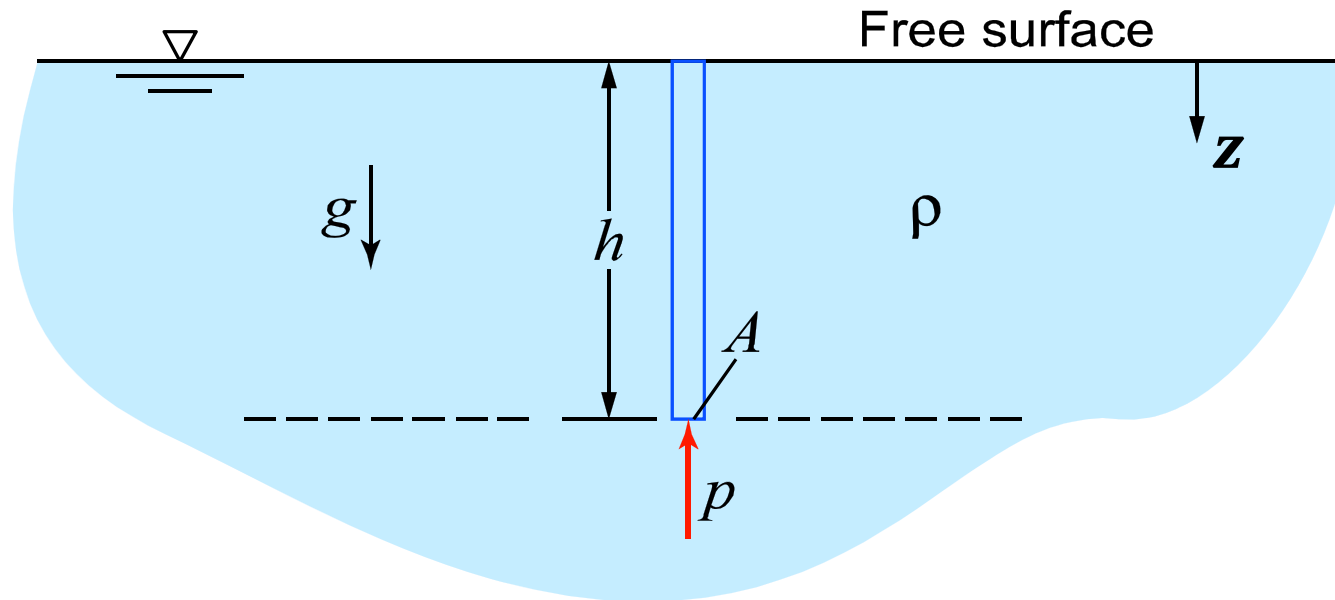
$$\Sigma F_y = 0: \quad p_y (A \sin \theta) - p A \sin \theta = 0 \quad \Rightarrow \quad p_y = p.$$

Thus, $p_x = p_y = p$ for any angle θ . The Pascal's law holds for fluids, not solids.

Incompressible: An incompressible fluid is one for which the mass density ρ is independent of the pressure p . Liquids are generally considered incompressible. Gases are compressible, but may be approximated as incompressible if the pressure variations are relatively small.

Fluid Pressure

For an incompressible fluid at rest with mass density ρ , the pressure varies linearly with depth z



Summing forces in the vertical direction gives

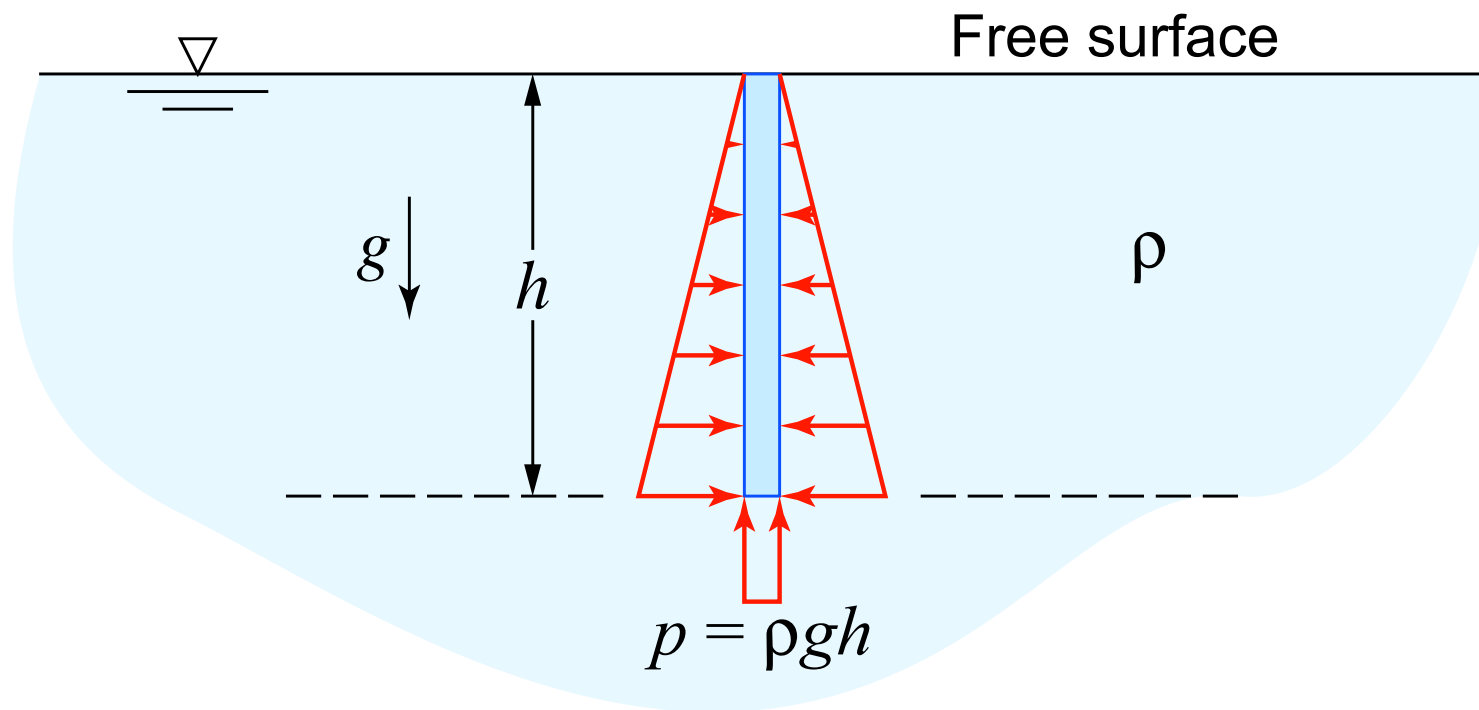
$$\Sigma F_x = 0: \quad mg - pA = 0 \quad \Rightarrow \quad (\rho(Ah))g - pA = 0 \quad \text{or} \quad p = \rho gh.$$

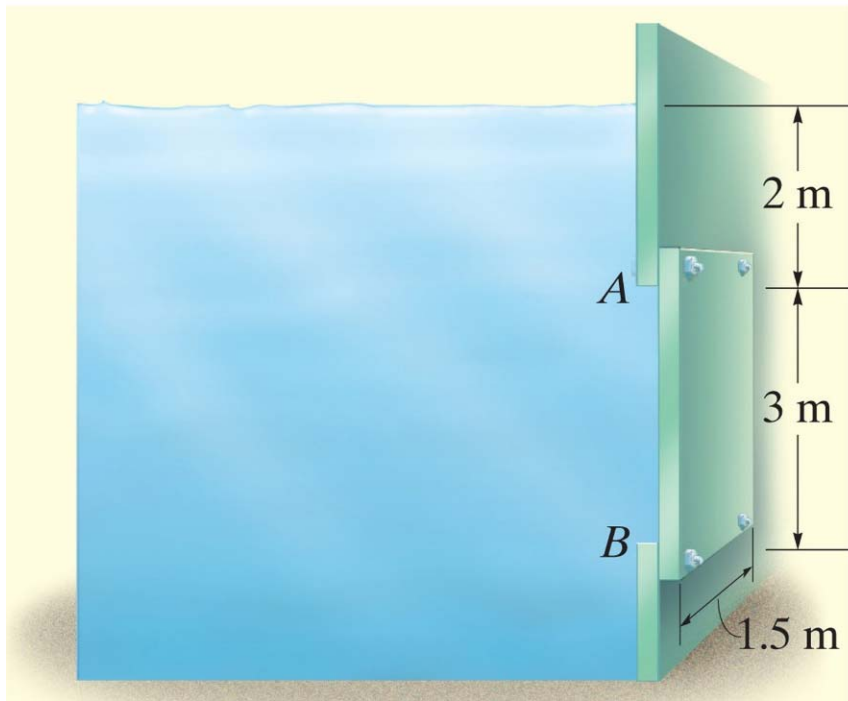
In general, this result is written as $p = \rho g z = \gamma z$

where $\gamma = \rho g$ is called the specific weight (weight per unit volume).

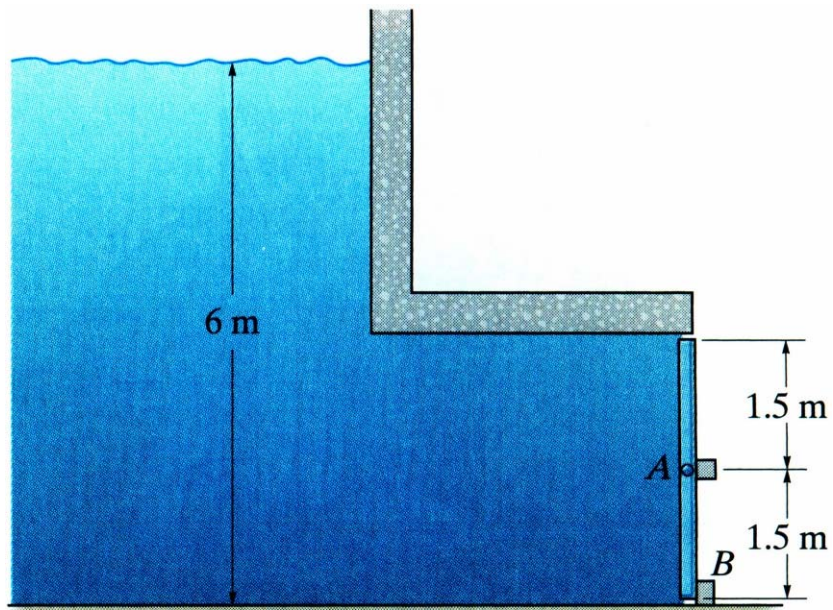
For fresh water: $\gamma = 62.4 \text{ lb/ft}^3$ (9810 N/m^3)

Observe that the pressure varies *linearly* from the free surface, and is *constant* along any horizontal plane (since h is constant):

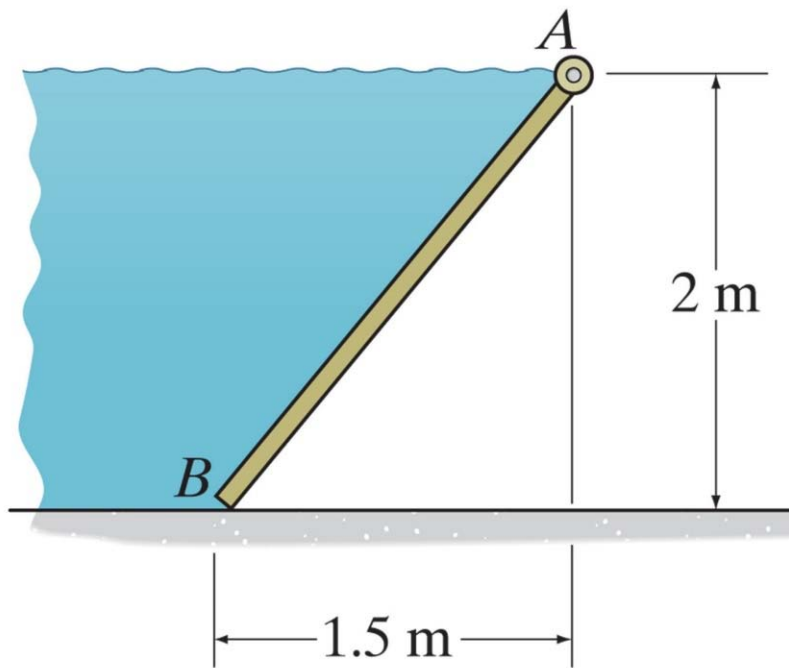




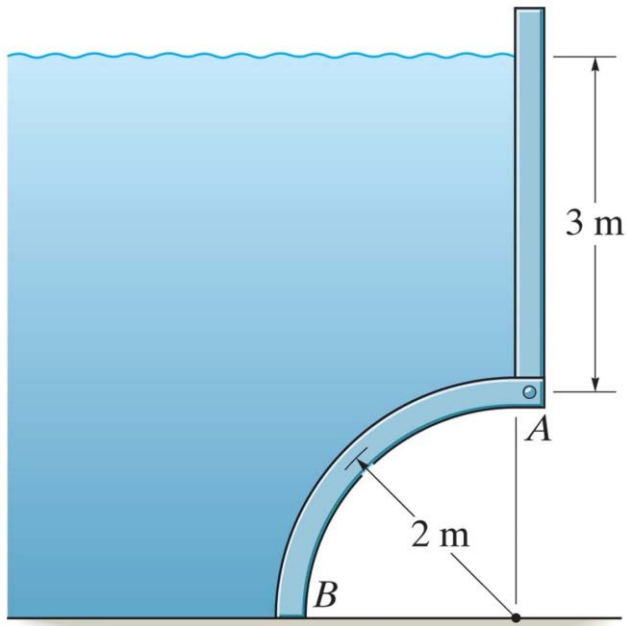
Determine the magnitude and location of the resultant hydrostatic force acting on the submerged rectangular plate AB. The plate has width 1.5m. The density of the water is 1000 kg/m^3



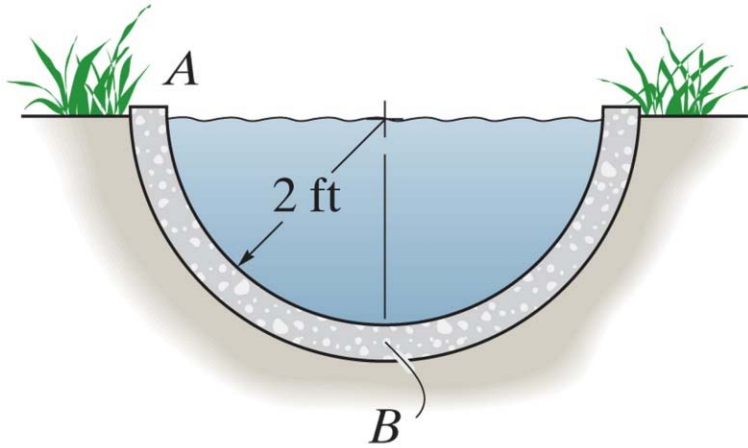
The 2m wide rectangular gate is pinned at its center A and is prevented from rotating by the block at B. Determine the reactions at these supports due to hydrostatic pressure. The density of the water is 1000 kg/m^3



Determine the magnitude of the resultant hydrostatic force acting on the gate AB. The gate has width 1.5m. The density of the water is 1 Mg/m^3



The arched surface AB is shaped in the form of a quarter circle. If it is 8 m long, determine the horizontal and vertical components of the resultant force caused by the water acting on the surface. The density of the water is 1 Mg/m^3



The semicircular drainage pipe is filled with water. Determine the resultant horizontal and vertical force components that the water exerts on the side AB of the pipe per foot of pipe length. The specific weight of the water is $\gamma = 62.4 \text{ lb/ft}^3$