Statics - TAM 211

Lecture 36

April 18, 2018

Chap 5.5-5.6, Chap 9.5

Announcements

- Upcoming deadlines:
  - Monday (4/23)
    - Mastering Engineering Tutorial 15
  - Tuesday (4/24)
    - PL HW 14
  - Quiz 6
    - CBTF (4/25-27)
  - Written Assignment 6
    - **Wednesday May 2**

Chapter 5 Part II – 3-D Rigid Body

Chap 5.5-5.6

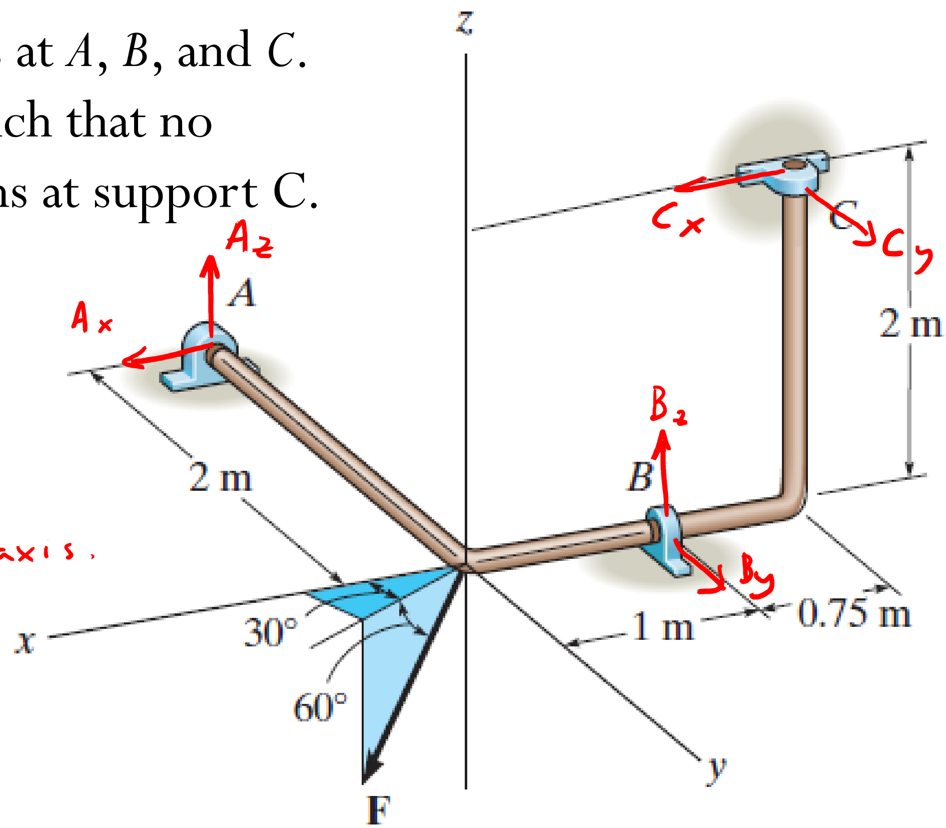
Recap: Equilibrium of a 3D rigid body

Six equations!

$\sum F_x = 0, \sum F_y = 0, \sum F_z = 0$
$\sum M_x = 0 \; \sum M_y = 0 \sum M_z = 0$

* Couple-moments are not applied to FBD if the body is supported elsewhere by additional bearings, pins or hinges that are **properly aligned** to prevent rotation in one or more axes).

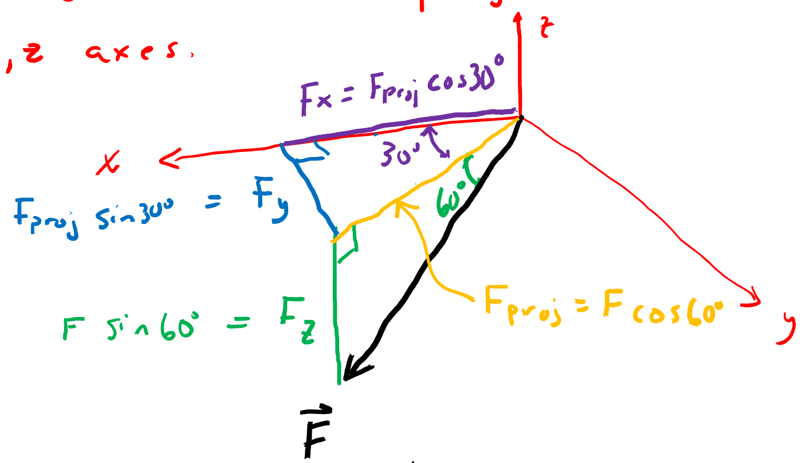
A bent rod is supported by smooth journal bearings at *A*, *B*, and *C*. F = 800 N. The supports are **properly aligned** such that no moment support is present. Determine the reactions at support C.



Pointers for this problem:

1) Bearings are properly aligned
   ⇒ No couple-moments at bearings
   Since JOURNAL bearings, only have reaction forces in axes ⊥ to shaft axis.

2) For applied force $\vec{F}$, need to consider how $\vec{F}$ will project onto x, y, z axes.



$$\vec{F} = F_x \hat{i} + F_y \hat{j} + F_z \hat{k}$$

$$\vec{F} = (F \cos 60°) \cos 30° \hat{i} + (F \cos 60°) \sin 30° \hat{j} - F \sin 60° \hat{k}$$

Chapter 9 Part II – Fluid Pressure

Chap 9.5

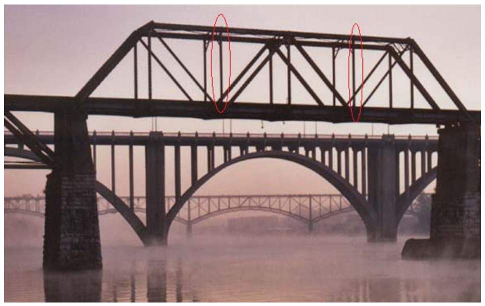
Goal and objective

- Present a method for finding the resultant force of a pressure loading caused by a fluid

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

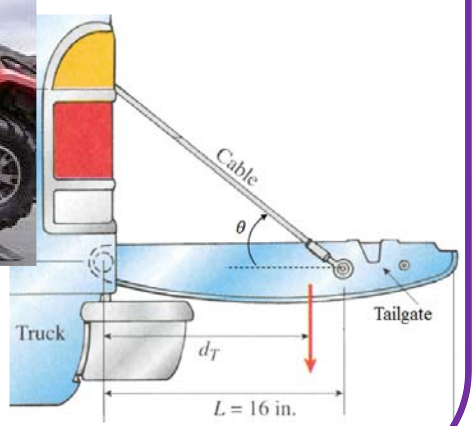
Rigid Bodies



TAM 210/211: Statics

TAM212: Dynamics

Deformable Bodies

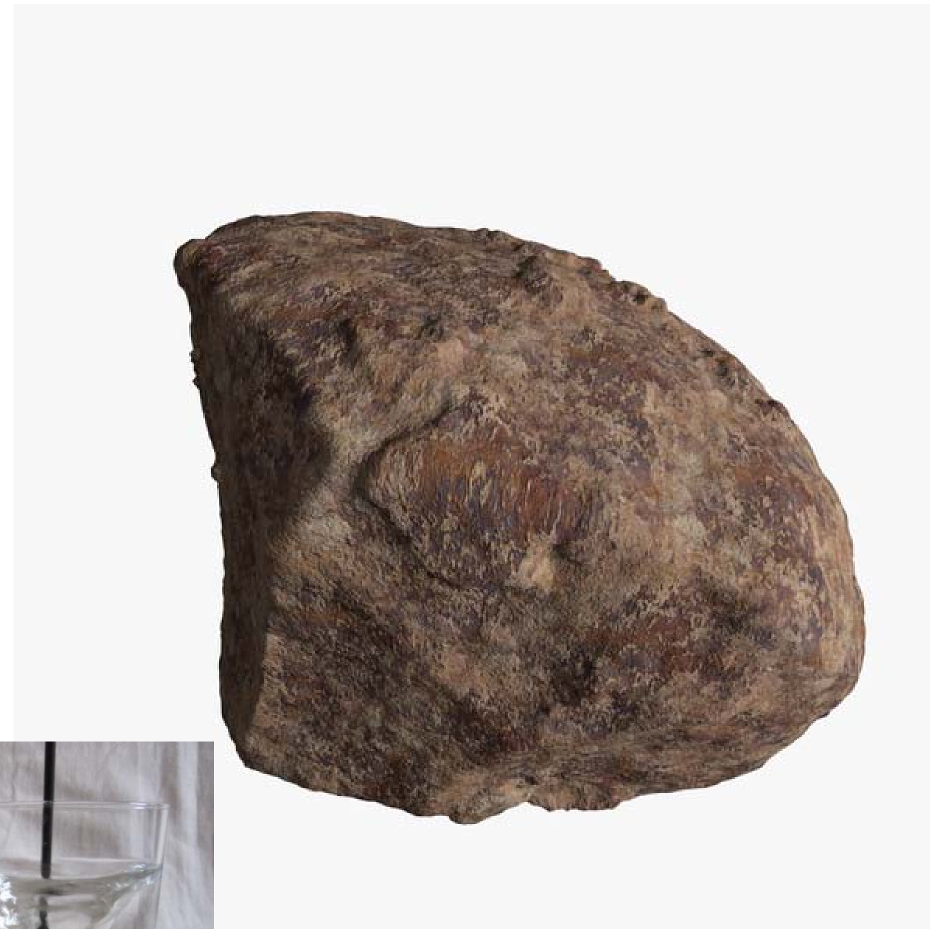


TAM 251: Solid Mechanics

FLUIDS

What Makes a Fluid or Solid?

Honey

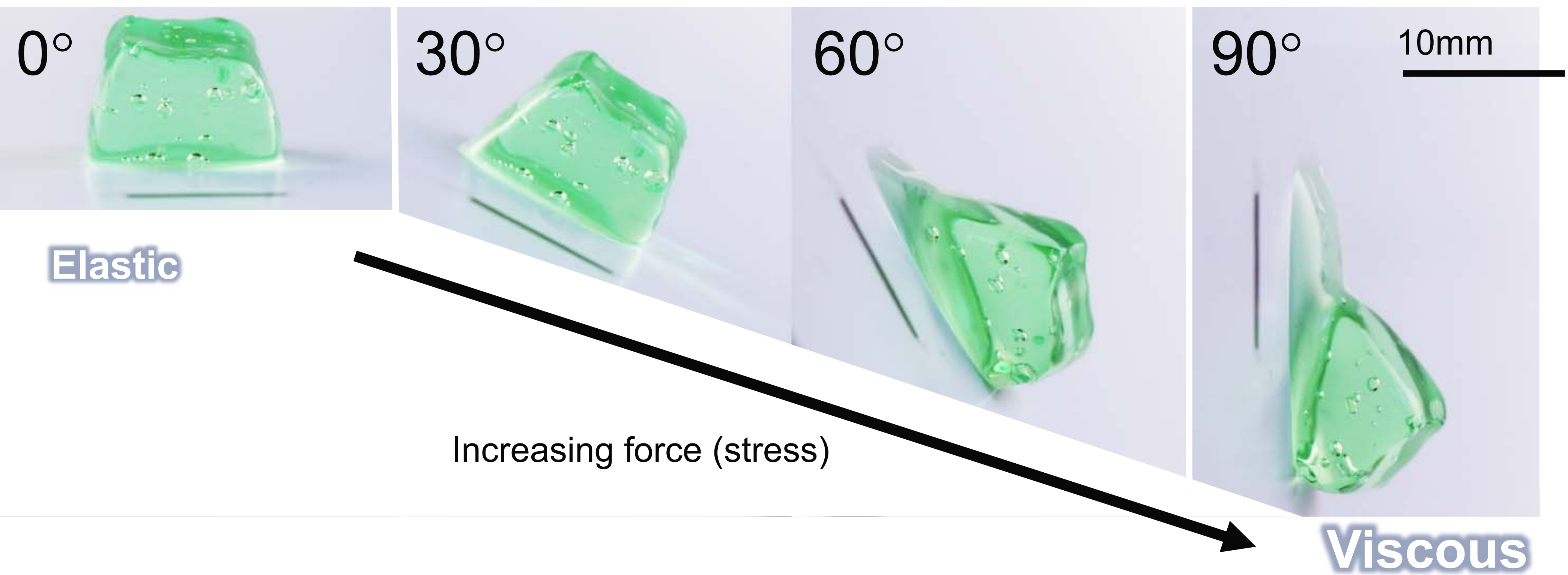


Rock

What is Sand?

Particles swollen with water – 'Squishy Baff'

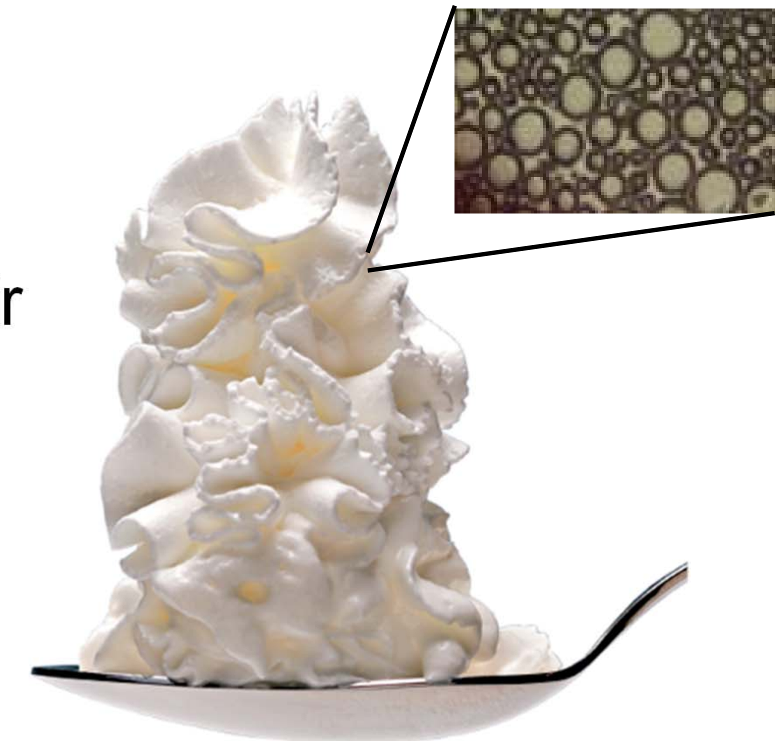
Aloe Gel



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

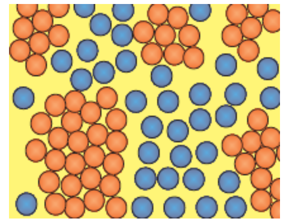
mechanical beating

They look like a fluid...

Video

cornstarch + water =

(small, hard particles)



But they may bear static loads like solids

Summary

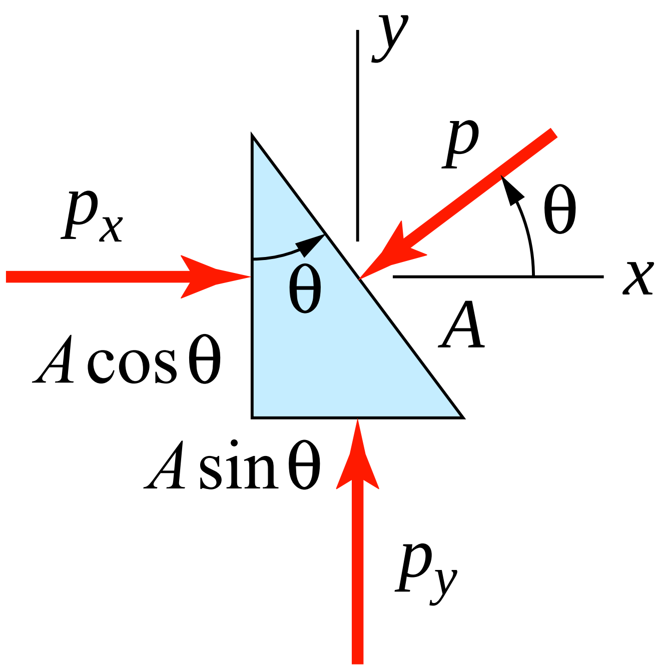
Water takes shape of its container. Rock does not. → Water and rock fit classical definitions of fluid and rock respectively

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

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



For equilibrium of an infinitesimal element,

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

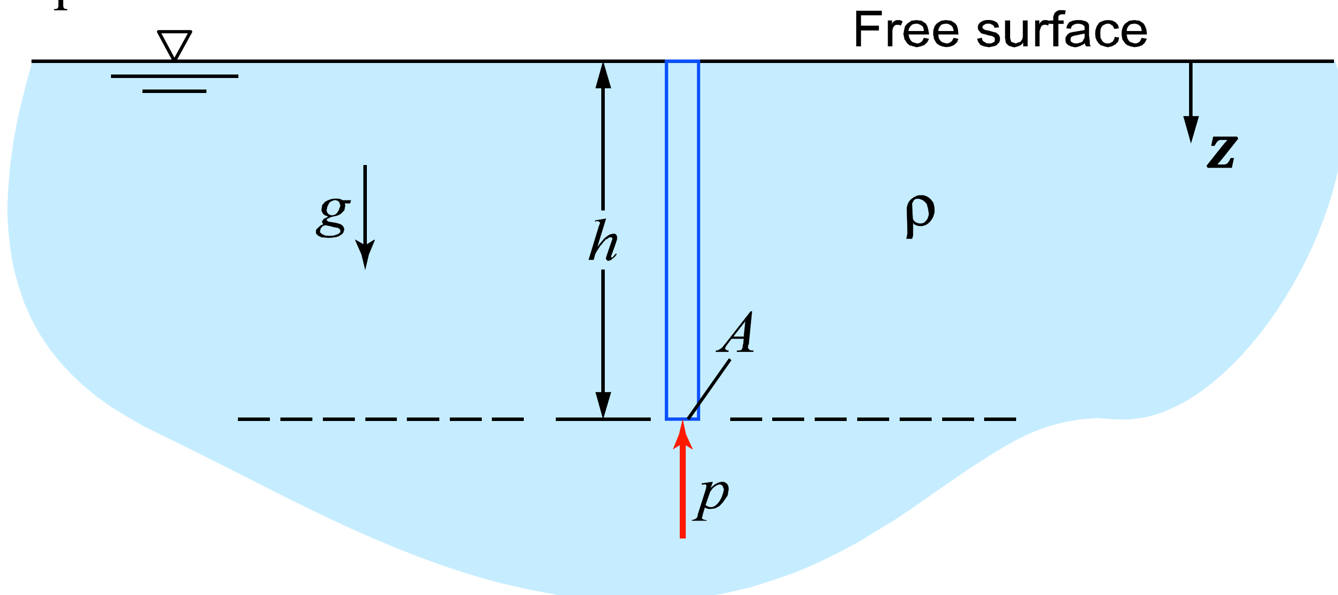
$$\Sigma F_y = 0: \quad p_y\left(A\sin\theta\right) - pA\sin\theta = 0 \quad \Rightarrow \quad p_y = p.$$

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

<u>Incompressible</u>: 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

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

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: γ =62.4 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):