M E 320 – Fluid Flow

Today, we will:

- Introduce the course and instructor: **John M. Cimbala, 863-2739, jmc6@psu.edu**
- Briefly go over the course website at **www.mne.psu.edu/me320-1** ☆
- Introduce fluid mechanics – What is a fluid? What is mechanics?
- Begin a discussion about classification of fluid flows

I. INTRODUCTION

FLUID FLOW or FLUID MECHANICS

I. Introduction

A. What is Fluid Mechanics? (Let's develop definition of fluid & mechanics)

A FLUID IS A LIQUID OR GAS → Solid: liquid, gas

W/o surface effects, liquids & gases behave the same

exceptions:
- Free surface effects
- high speed flow (compressible flow)

Defn of a fluid

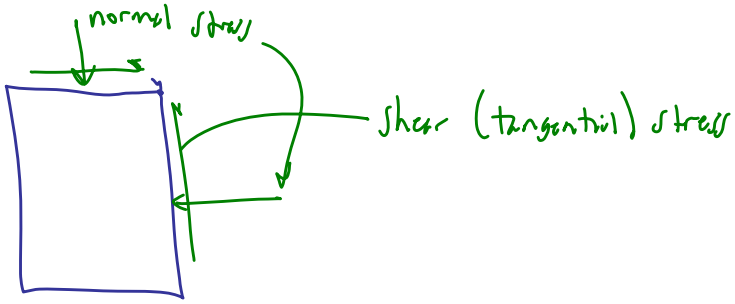
Fluid = A substance that deforms continuously under the application of a shear stress ☆

Shear stress: Stress = force/area

normal + shear stresses

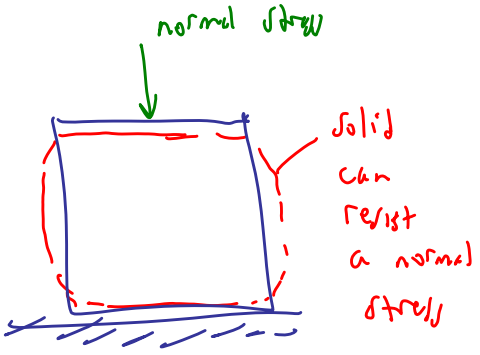
FBD:

(free body diagram)

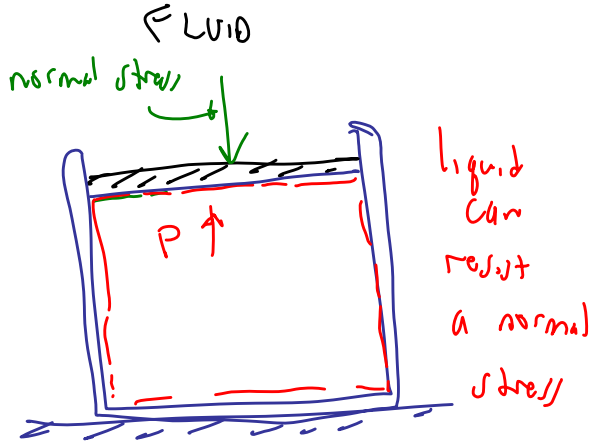


Compare solid & fluid:

SOLID



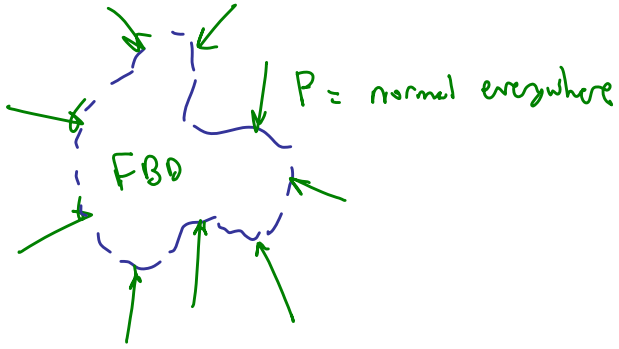
FLUID



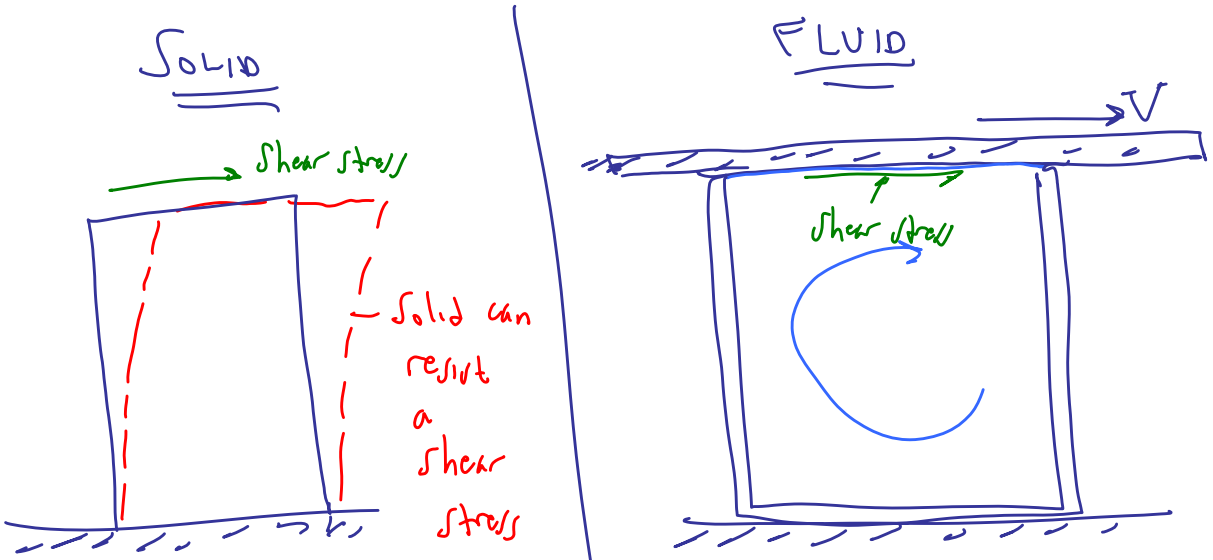
(P goes up)

Normal stress in a fluid is the pressure, P

Pressure is always inward & normal

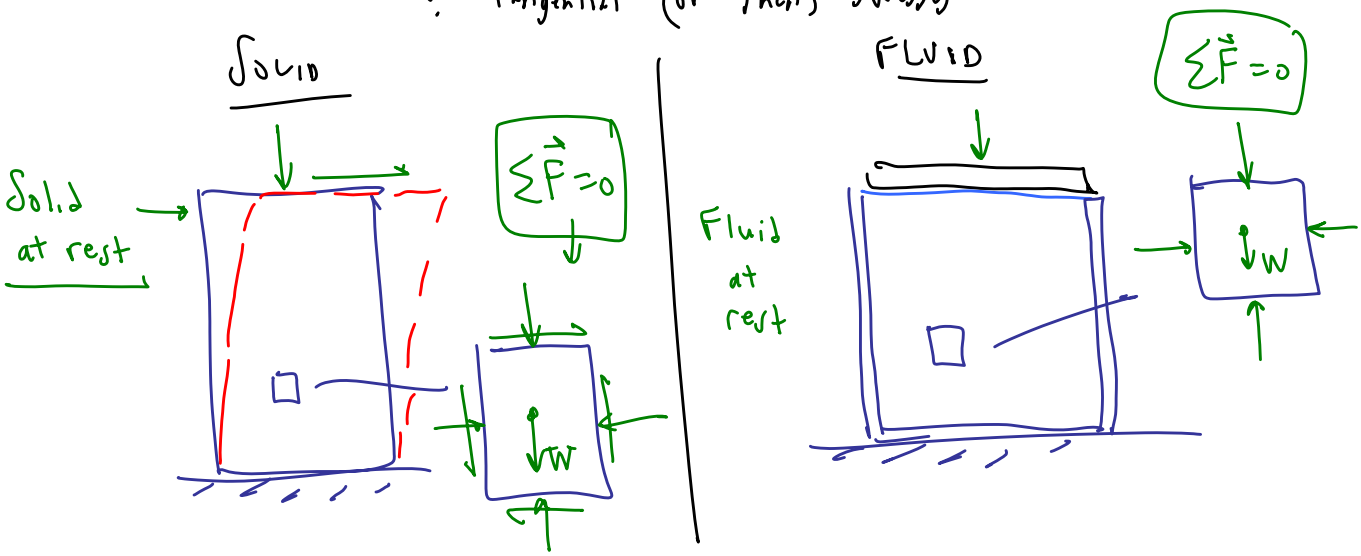


Shear stress:

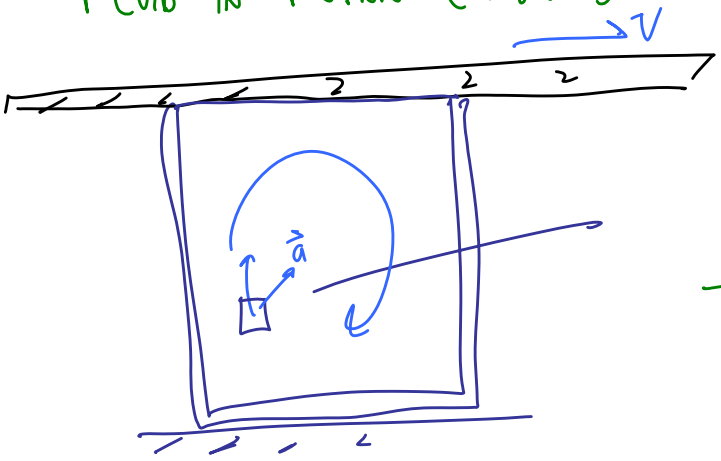


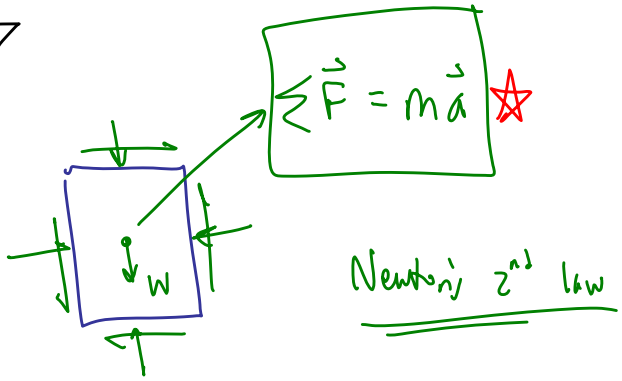
A fluid at rest cannot resist a shear stress (it will deform) ★

When in motion — both solids & fluids can have both normal & tangential (or shear) stresses



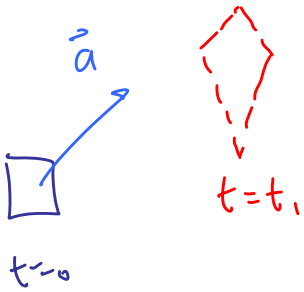
FLUID IN MOTION (caused by a shear stress)





Newton's 2nd law

This is why fluid mechanics is more complicated than solid mechanics



Fluid element moves & distorts as it flows

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2. Mechanics — fluid mechanics

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The application of laws of motion & force

two branches → statics & dynamics

Fluid mechanics → 1) Fluid statics or hydrostatics → fluids at rest

$\sum \vec{F} = 0$

2) Fluid dynamics → fluids in motion $\sum \vec{F} = m\vec{a}$

B. Classification of Fluid Flows (see text for details)

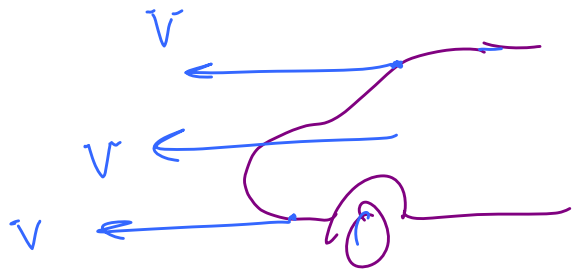
1. Viscous vs. Inviscid regions of flow

does not mean no viscosity or no friction

All fluids have viscosity and are viscous

* Viscous effects are negligible

eg. car moving through air



No-slip condition

$\vec{V}_{fluid} = \vec{V}_{air}$

at a solid-fluid interface *

FOR → wind tunnel

(frame of reference)

In a boundary layer, viscous effects are important — viscous region of flow

Outside the b.L., viscous effects are not important — inviscid region of flow