NOTES LECTURE 10-17-2017

FORCE → SYSTEM — FOOD, PHARMACEUTICAL, CELL, TISSUE.

FORCE → STRESS $= \frac{F}{A}$ → SO STRESS IS FUNCTION OF MATERIAL

SYSTEM → DEFORMATION or FLOW

DEFORMATION → $\frac{\text{DEFORMATION}}{\text{INITIAL DEFORMATION}} \equiv$ STRAIN [NO UNITS]

FLOW → STRAIN/RATE

MECHANICAL PROPERTIES

MECHANICAL PROPERTIES ARE RELATED TO THE RELATIONSHIP BETWEEN THE FORCE & DEFORMATION (SOLIDS) OR FORCE & ~~DEF.~~ FLOW (FOR LIQUIDS)

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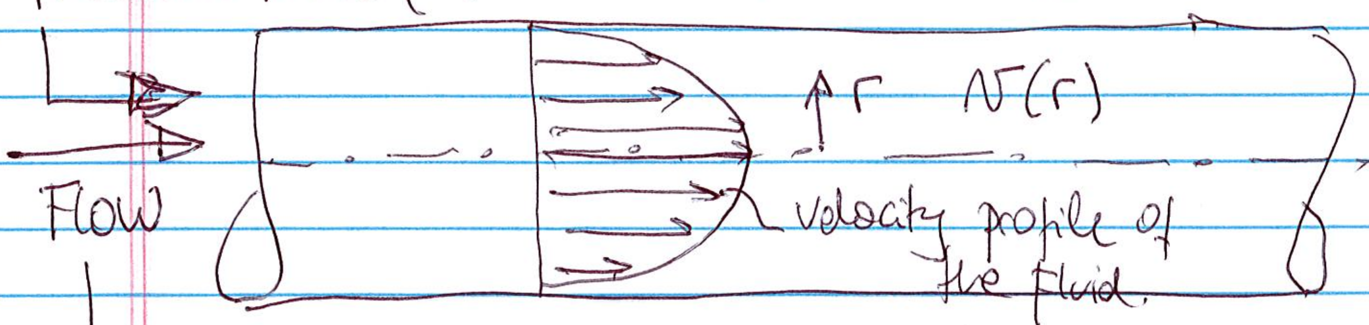
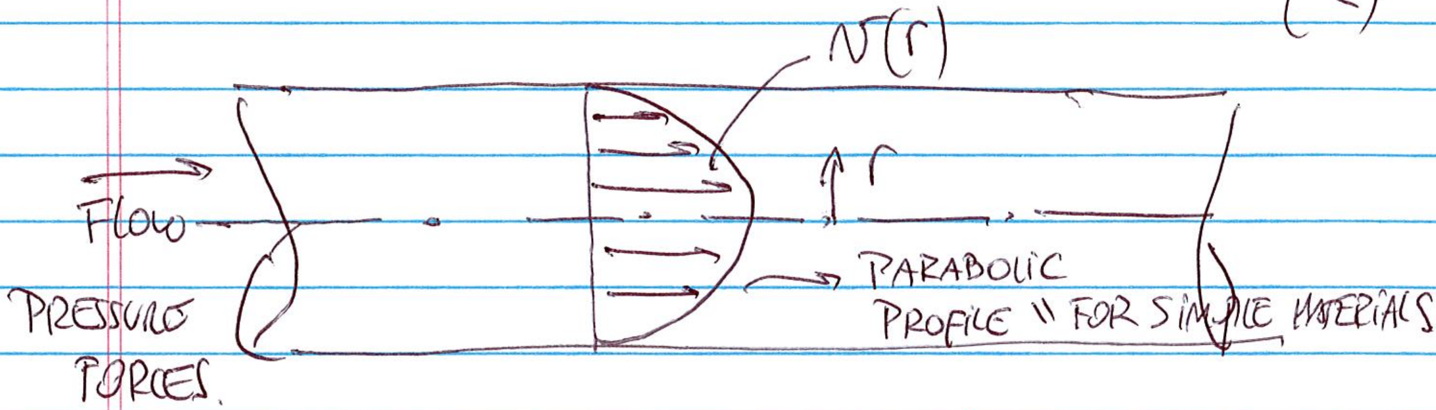
PRESSURE FORCE ⟺ STRESS (slide 8 τ_{12})



FLOW → STRAIN RATE → Slide $\dot{\gamma}$ ← shear rate

VISCOSITY → $\mu = \frac{\tau_{12}}{\dot{\gamma}}$

"MECHANICAL PROPERTY



$v(r)$ = velocity profile.

$\frac{dv(r)}{dr}$ = GRADIENT OF VELOCITY [NEGATIVE]

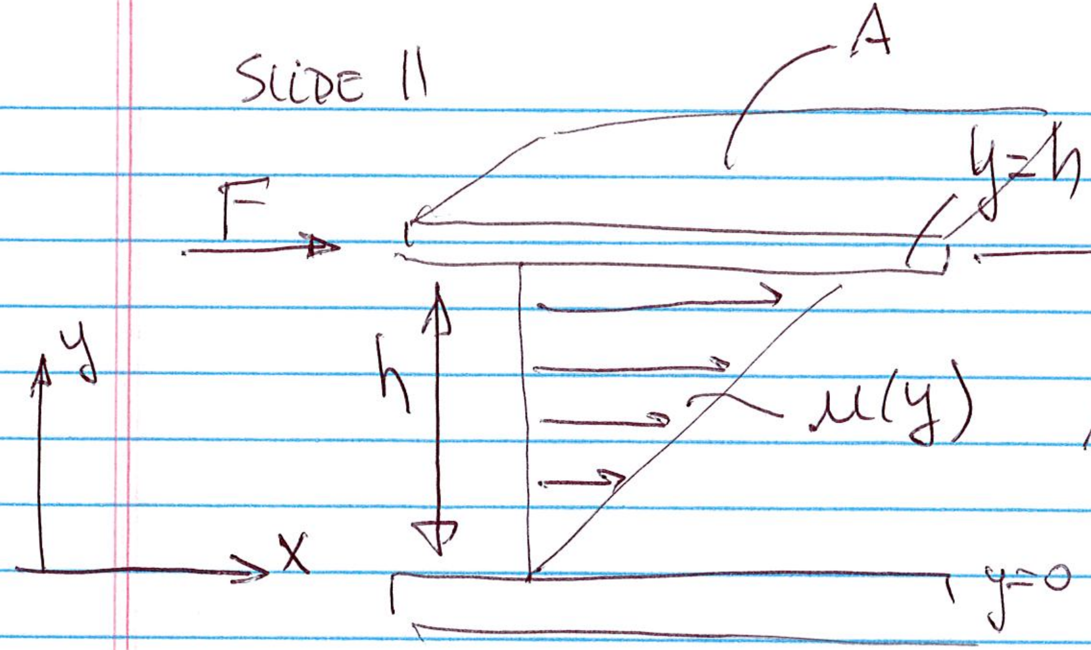
HOW TO RELATE GRADIENT OF VELOCITY $\frac{dv(r)}{dr}$ WITH PRESSURE FORCES?

Newton's law of viscosity

$$\boxed{\tau = -\mu \underbrace{\frac{dv(r)}{dr}}_{\dot{\gamma}\ \text{(shear rate)}}}$$

stress

SLIDE 11



$$u(y) = \begin{cases} 0 & y=0 \\ V & y=h \end{cases}$$

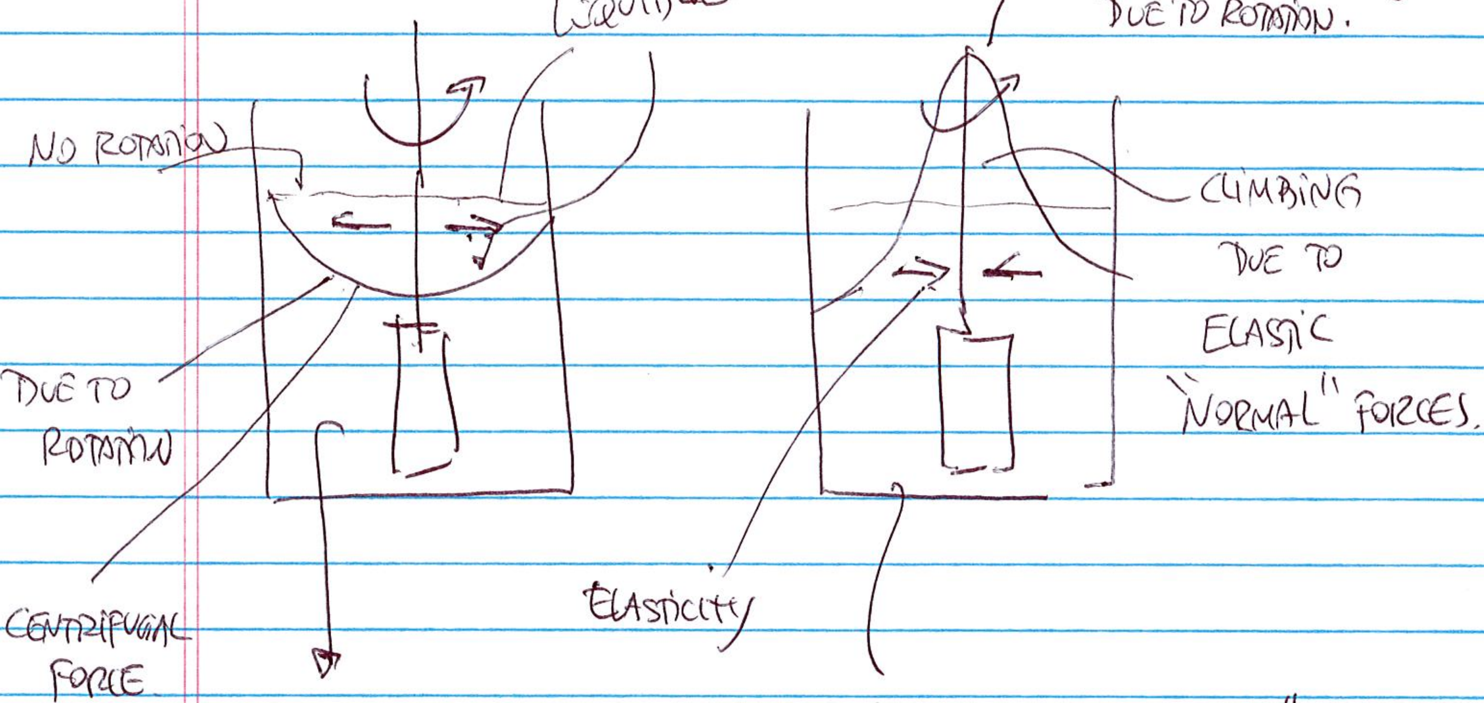
$\frac{du(y)}{d\cancel{x}y}$ = VELOCITY GRADIENT.

SLOPE OF THE PROFILE.

$$\frac{du(y)}{dy} = \frac{V}{h} = \dot{\gamma}$$ ← SHEAR RATE

$$\frac{F}{A} = \tau$$ ← SHEAR STRESS

NON-ELASTIC LIQUIDS



GLYCERINE

GLYCERINE + PART PER MILLION OF A POLYMER

VERY LITTLE → SO YOU DON'T CHANGE VISCOSITY

$$\mu = \frac{\text{SHEAR STRESS}}{\underbrace{\text{SHEAR RATE}}_{\text{STRAIN RATE}}} = \frac{\sigma}{\dot{\gamma}} = \frac{Pa \left(\frac{F}{A} = \frac{N}{m^2} = Pa\right)}{\frac{\text{NO UNITS}}{s}}$$

$$\mu = \frac{Pa}{1/s} = Pa.s$$

$\mu = Pa.s$ (5)

$$Pa = \frac{N}{m^2} = \frac{1\,Kg\,\frac{\cancel{m}}{s^2}}{m^{\cancel{2}}} = \frac{Kg}{m\ s^2}$$

$$1\,Pa = 1\,\frac{Kg}{m.s^2}$$

$$\mu = \boxed{Pa.s = 1\,\frac{Kg}{m s^{\cancel{2}}} \times \cancel{s} = \frac{Kg}{m.s}}$$

Viscosity OF WATER = 1 CP = 10^{-2} poise.

"centi"

$$\boxed{Poise = \frac{g}{cm.s}}$$

$$1\,Pa.s = \frac{\cancel{Kg}}{\cancel{m} \times s} \times \frac{1000\,g}{1\cancel{Kg}} \times \frac{1\cancel{m}}{100\,cm} = \frac{1000}{100}\ \underbrace{\frac{g}{cm.s}}_{poise}$$

$$1\,Pa.s = \frac{1\,poise}{\underbrace{100}_{CP}} \times 1000 = \underline{1000\,CP}$$

$$\boxed{1\,Pa.s \equiv 1000\,CP}$$

Viscosity of water $= 1\,CP = \underbrace{\frac{1}{1000}\,Pa.s}_{m\,Pa.s}$

$\boxed{\text{Milli } Pa.s}$

$$\boxed{1\,CP \equiv 1\,m\,Pa.s}$$

NEWTON MODEL (SIMPLE NEWTONIAN FLUIDS)

$$\tau = \mu \dot{\gamma}$$

— PROPERTY is viscosity

NON-NEWTONIAN MODEL

$$\tau = K \dot{\gamma}^n$$

PROPERTIES ARE K & n

Why units of K ARE $Pa.s^n$? (7)

$$\tau = K \times \dot{\gamma}^{1/n}$$

$$Pa = \quad \times \left(\frac{1}{s}\right)^n = Pa.\cancel{s^n} \times \frac{1}{\cancel{s^n}}$$