Elasticity - Relates to amount of deformation for a given pressure change!

Water is usually considered to be incompressible
(≈100 times more compressible than steel)

E_b - bulk modulus of elasticity

$$\Delta P = -E_b \left(\frac{\Delta Vol}{Vol}\right)$$

Vol - initial volume

ΔP = change in pressure

ΔV = change in volume

E_b water = 2.2×10^9 N/m² (311,000 psi) (20°C)

Example (1.57)

What pressure is required to reduce volume of water by 0.5% (.005) ? (Temp = 20°C)

$\Delta P = (311{,}000\ psi)\left(\frac{.005}{1}\right)$ or $(2.2\times10^9\ N/m^2)(.005)$

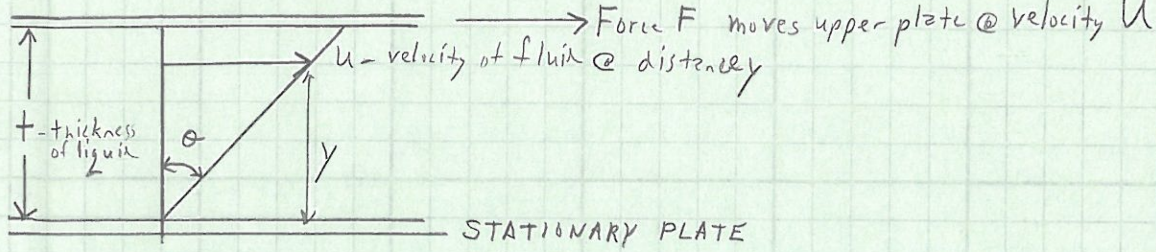
$\boxed{\Delta P = 1{,}555\ psi}$ = $\boxed{1.1\times10^7\ N/m^2}$

→ 3/4 of a ton per square inch

Viscosity

A factor related to resistance to shear forces

for a Newtonian FLUID



Shear stress, $\tau = \frac{F}{A} = \mu \frac{du}{dy}$ — shear rate

$\frac{F}{A}$: Force divided by area of upper plate

$\frac{du}{dy}$: velocity gradient - rate @ which one layer moves relative to an adjacent layer

μ: constant; dynamic (absolute) viscosity

- the fluid @ the boundary has the same velocity as the boundary (i.e. u @ stationary plate $= 0$ & $u = U$ @ upper plate $y = t$) - there is no slip (experimental observation)

Dynamic (absolute viscosity)	μ	$\frac{N \cdot sec}{m^2}$	$\frac{lb \cdot sec}{ft^2}$	App. A. Fig. A.2 & A.3
Kinematic Viscosity $= \frac{\mu}{\rho_a}$ (mass density)	ν	m^2/sec	ft^2/sec	Also Tables A4 & A5

→ Newtonian - linear relationship between the shear stress & the rate of deformation (gases + most liquids)

→ Non-Newtonian - nonlinear relationship (thick, long-chained hydrocarbons)

high viscosity - honey, tar
low viscosity - water, air

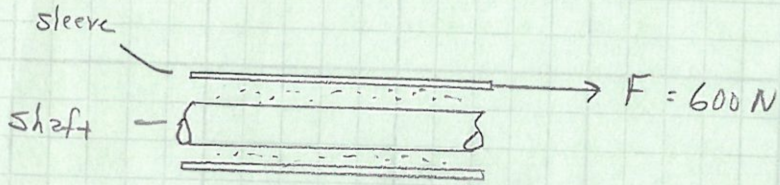
Viscosity - examples

Prob. 1.12 (pg 23)

A Newtonian fluid is in the clearance between a shaft and a concentric sleeve. When a force of 600 N is applied to the sleeve parallel to the shaft, the sleeve attains a speed of 1 m/sec.

If a 1500-N force is applied, what speed will the sleeve attain?

The temp. of the sleeve remains constant.



$$\frac{F}{A} = \mu \frac{du}{dy}$$

(μ: viscosity; dy: dist.)

If F = 1500 N then speed = $\left(\frac{1500\,N}{600\,N}\right)(1\ m/sec) = 2.5\ m/sec$