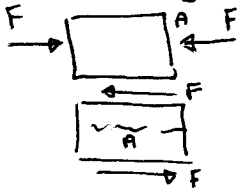
Sept. 5/18

Final - 50 %
Midterm - 40 %. (Oct. 3rd - Wednesday, 8-10 pm)
Assignments - 10 %

Fluid dynamics → Study of Fluid at rest (Fluid statics)
" motion (Fluid dynamics)

Fluid → distinction between a solid / fluid is made on the basis of the substances ability to resist applied shear stress.
↳ material that can't resist shear stress

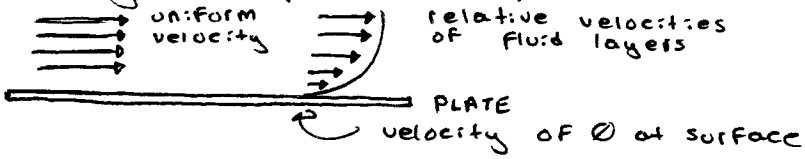


Normal stress = $\sigma = F/A$

Shear stress = $\tau = F/A$

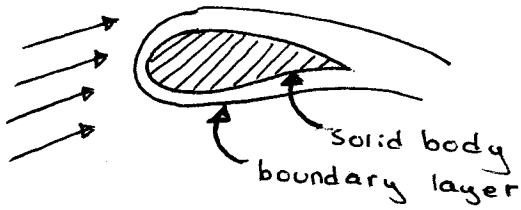
In Fluid at rest, normal force is called pressure

No-slip condition - velocity of Fluid is equal to velocity of plate at point of contact



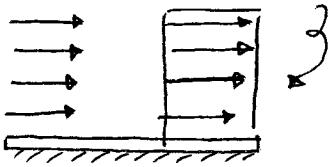
There is slip-conditions in instances of very small diameter pipes.

boundary layer thickness - δ
↳ thickness of Fluid that sticks to point of contact (separation between uniform velocity / zero velocity transition)
- Invicid Flow region (above boundary)
- viscous Flow region (inside boundary layer)

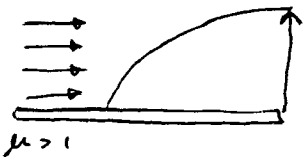


1) invicid vs viscous

If you have a fluid with no viscosity, the profile would look like the uniform velocity profile.

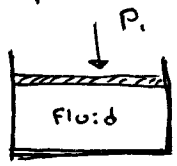


very viscous fluid:

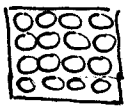


2) Internal vs. External Flow (wind tunnels, etc...)

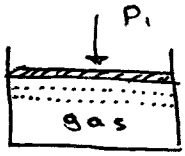
3) Compressible vs. Incompressible Flow

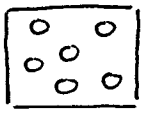


$\rho_{liq} \approx$ const.



(Fluids are not compressible)





Mach number

$$Ma = \frac{V}{c} = \frac{\text{Speed of Flow}}{\text{Speed of Sound}}$$

(c = 346 m/s at air temp/sea level)

A Flow is called Sonic when $Ma = 1$
" " Subsonic when $Ma < 1$
" " Supersonic when $Ma > 1$
" " hypersonic when $Ma >> 1$

Gas Flows can often be approximated as incompressible if the density changes are under about 5% (usually the case when $Ma < 0.3$)

4) Laminar vs. Turbulent

laminar - smooth, glass-like → $Re < 2000$ Laminar Flow
turbulent - mixing layers → $Re > 4000$ Turbulent Flow

Reynold's number

$$Re = \frac{\rho U L_{ef}}{\mu}$$

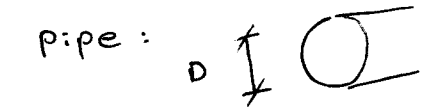
ρ - density
μ - dynamic viscosity
U - velocity (mean)
L_{ef} - effective length

OR

$$Re = \frac{U L_{ef}}{\nu}$$

ν = Kinematic viscosity

For a pipe:

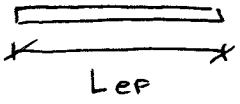


$L_{EF} = D$

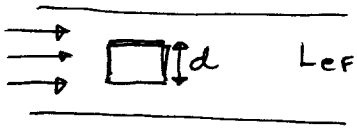
$L_{EF} = D_{cyl}$

$L_{EF} = D_{hyd}$

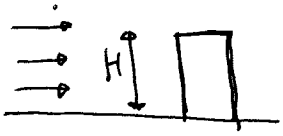
For a plate:



L_{EF} = length of plate



$L_{EF} = d$



$L_{EF} = H$

5) Natural vs. Forced Flow
Forced Flow - fluid forced to flow over a surface or in a pipe by external means
Natural - natural means (buoyancy, etc.)

6) Steady vs. Unsteady Flow
steady - no change at a point with time
unsteady - the opposite

Uniform Flow - same throughout, any location
steady - same at that point in time