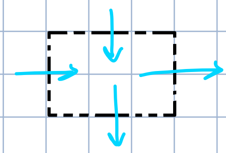
Branch of mechanics - Motion of fluids and forces acting on bodies in relative motion

Fluid dynamics uses Eulerian View : fixed box - control volume where fluid continuously moves through



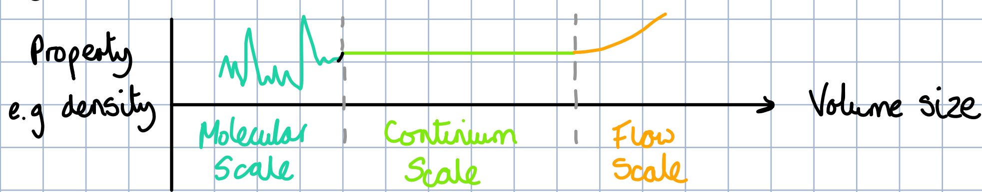
Moving fluid = no fixed mass

$$\therefore \sum F = \frac{d}{dt}(mv)$$

Continuum Approximation :

Assumes fluid made of continuous medium divided into small volumes that are:

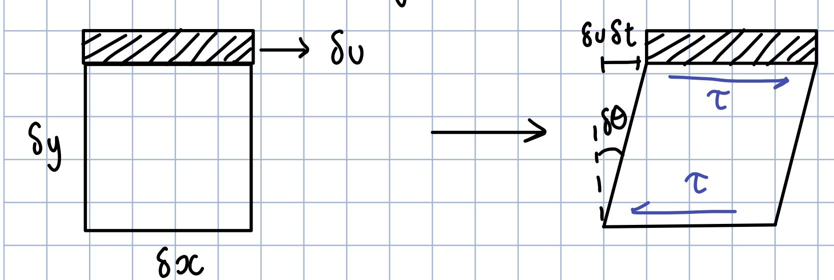
- Many times smaller than smallest characteristic length scales of flow
- large enough (contain enough molecules) for statistical averages to be unchanged by variations in volume size



region where we can pretend molecules don't exist

Viscosity :

Consider fluid element that is sheared in one direction where the top is stuck to a 'surface'



$$\tan \delta\theta = \frac{\delta u \, \delta t}{\delta y} = \delta\theta \quad (\text{as } \theta \to 0)$$

$$\frac{\delta u \, \delta t}{\delta y} = \delta\theta \quad \therefore \boxed{\frac{\delta\theta}{\delta t} = \frac{\delta u}{\delta y}}$$

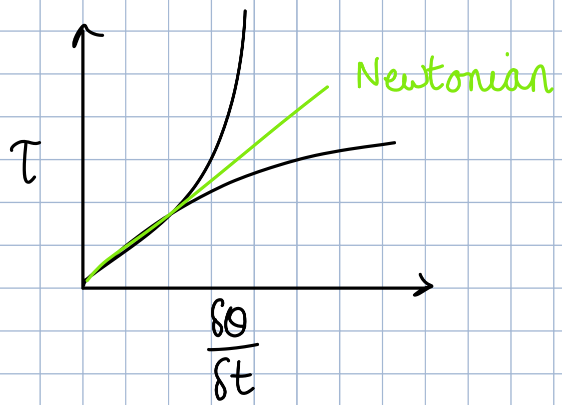
and so for Newtonian fluids, the shear stress (τ), is directly proportional to the velocity gradient, where the viscosity coefficient, μ, is the constant of proportionality :

$$\tau \propto \frac{\delta\theta}{\delta t} \quad \text{and} \quad \tau = \mu \frac{\delta u}{\delta y}$$

Viscocity continued ...

- Viscocity causes the shear (boundary) layer of slower moving fluid near a solid surface.
- Strong function of temperature, weak function of pressure

Newtonian Fluid : viscous stresses correlate linearly with shear stress rate



Velocity Profiles :

Consider fluid flowing over curved surface :

n : surface normal defines points where tangential velocity is measured

velocity profile represents magnitude of the 2D tangential velocity of fluid as you move away from surface in normal direction.

→ 0 velocity at surface