Transport Phenomena

Objective: investigate transport properties of heat, mass and momentum

Focus: Diffusive fluxes and material properties

Fluxes in properties (e.g. energy) occur due to nonuniformity

$\Rightarrow$ property gradients (driving forces) that tend to disappear over time.

$\Rightarrow$ Spontaneous dissipation of property gradients

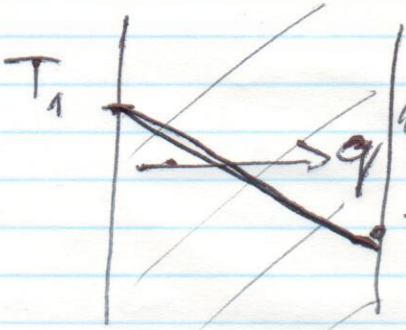
$\rightarrow$ motions from higher concentrations to lower concentrations

goal: Develop and apply constitutive eqs that relate fluxes to local material properties.

Ex: Heat Conduction: Consider a stationary fluid

→ diffusive process

(in contrast to a convective process)



$q'' \equiv \frac{Q}{A}$ heat flux due to the temp. gradient (A: area)

heat rate: $q = \left[\frac{J}{s}\right] = [W]$

Relationship between flux and $\frac{dT}{dz}$

⇒ Constitutive Eq: Fourier's Law of Heat Conduction

$$\boxed{q_z = -k \frac{dT}{dz}}$$

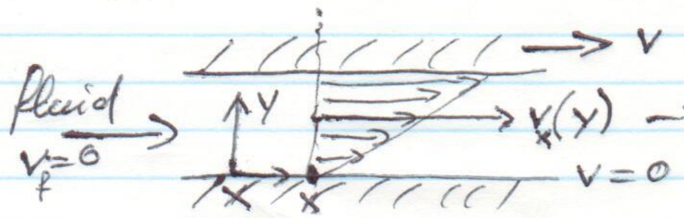
$k \,[=]\, \frac{W}{m \cdot K}$ thermal conductivity

Course Textbook: in 3D $\vec{q} = -k \vec{\nabla} T$

(Nomenclature: $\vec{\nabla} = \left(\frac{\partial}{\partial x}, \frac{\partial}{\partial y}, \frac{\partial}{\partial z}\right)$)

Fluid Mechanics

consider diffusive transport of momentum



→ property gradient $\frac{dv_x}{\partial y}$

⇒ Constitutive eq: Newton's law of viscosity

$$\boxed{\tau_{yx} = -\mu \frac{dv_x}{\partial y}}$$

stress $\frac{F}{A}$

μ [=] Pa·s viscosity

Diffusive Transport

Fourier's law of heat cond.: $q_z = -k \frac{dT}{dz} = -\alpha \frac{d}{dz}(\rho C_p T)$

(ρC_p = const; α: mass diffusivity)

Newton's law of viscosity: $\tau_{zx} = -\mu \frac{dv_x}{dy} = -\nu \frac{d}{dz}(v_x \rho)$

(ρ const.; ν: kinematic viscosity)

Fick's law: