TRANSPORT PHENOMENA

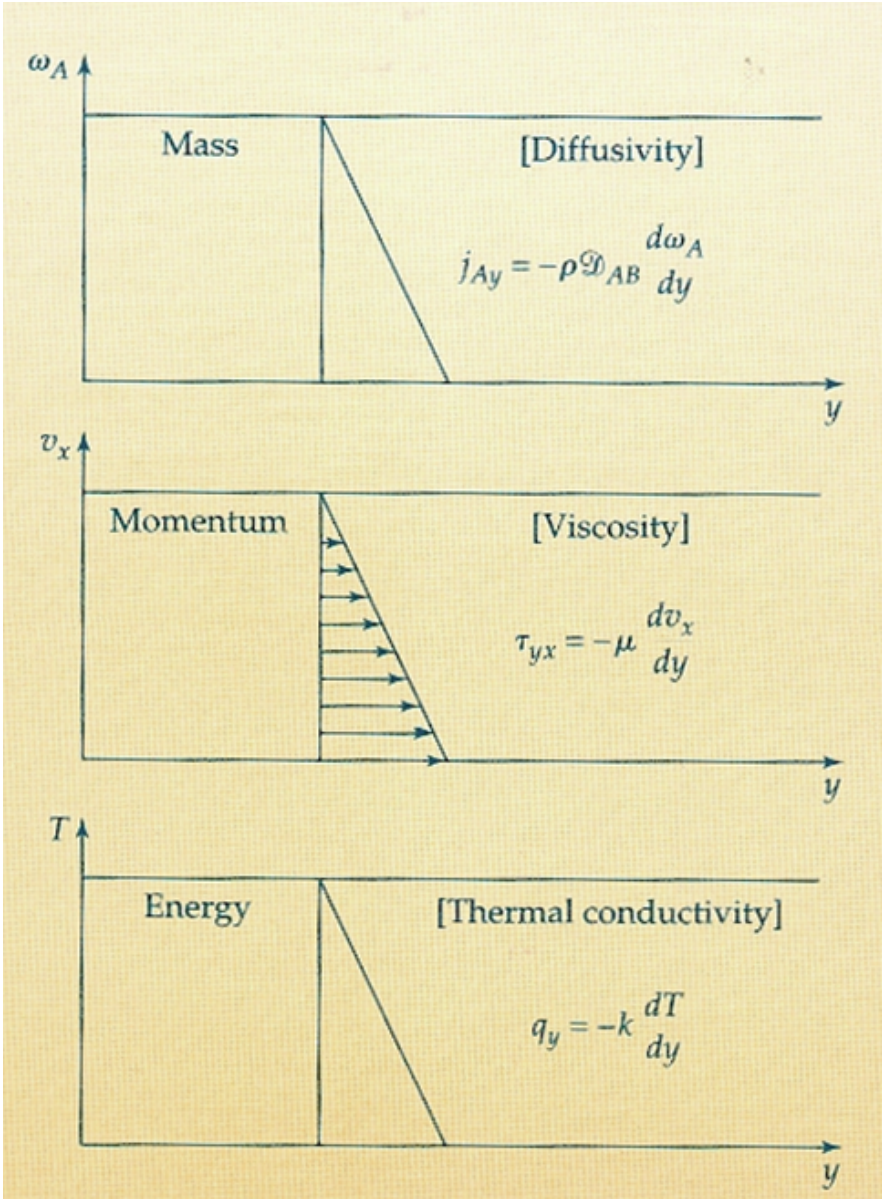
What are Transport Phenomena?

They include three closely related phenomena

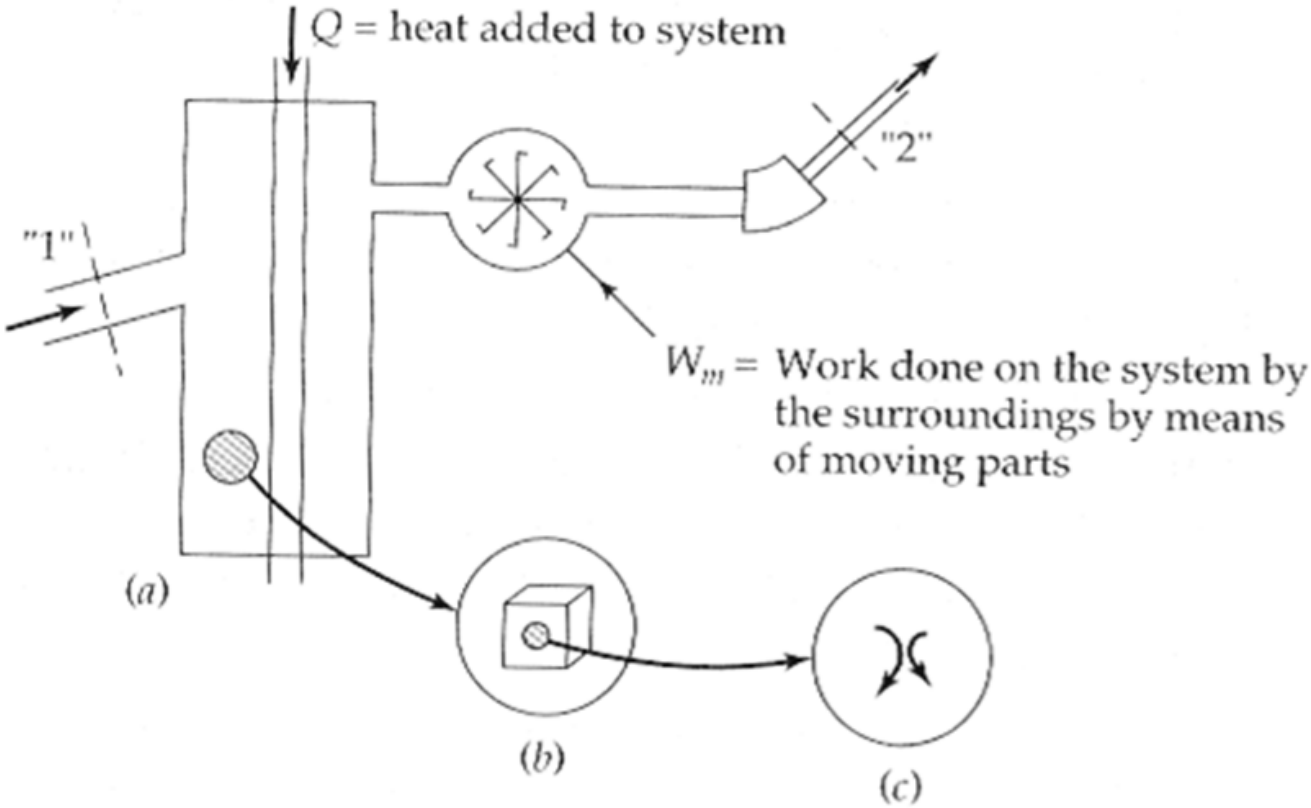
- ✓ Momentum transport — Fluid Mechanics (CHBE557)
- ✓ Energy transport — Heat Transfer
- ✓ Mass transport — Mass Transfer

Why studied together?

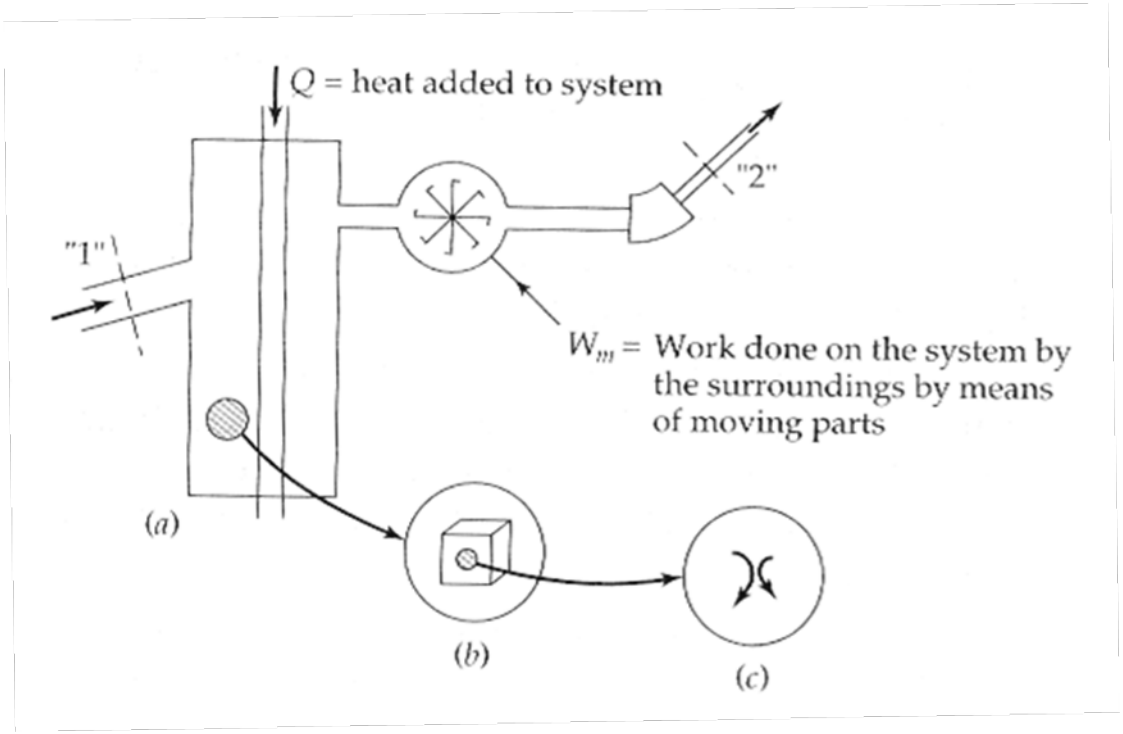
- ➢ Occur simultaneously in many disciplines of engineering
- ➢ Basic equations describing them are closely related
- ➢ Mathematical tools needed to describe them are similar
- ➢ Molecular mechanisms underlying the various transport phenomena are closely related


ω_A
Mass
[Diffusivity]
$j_{Ay} = -\rho \mathcal{D}_{AB} \frac{d\omega_A}{dy}$
y
v_x
Momentum
[Viscosity]
$\tau_{yx} = -\mu \frac{dv_x}{dy}$
y
T
Energy
[Thermal conductivity]
$q_y = -k \frac{dT}{dy}$
y

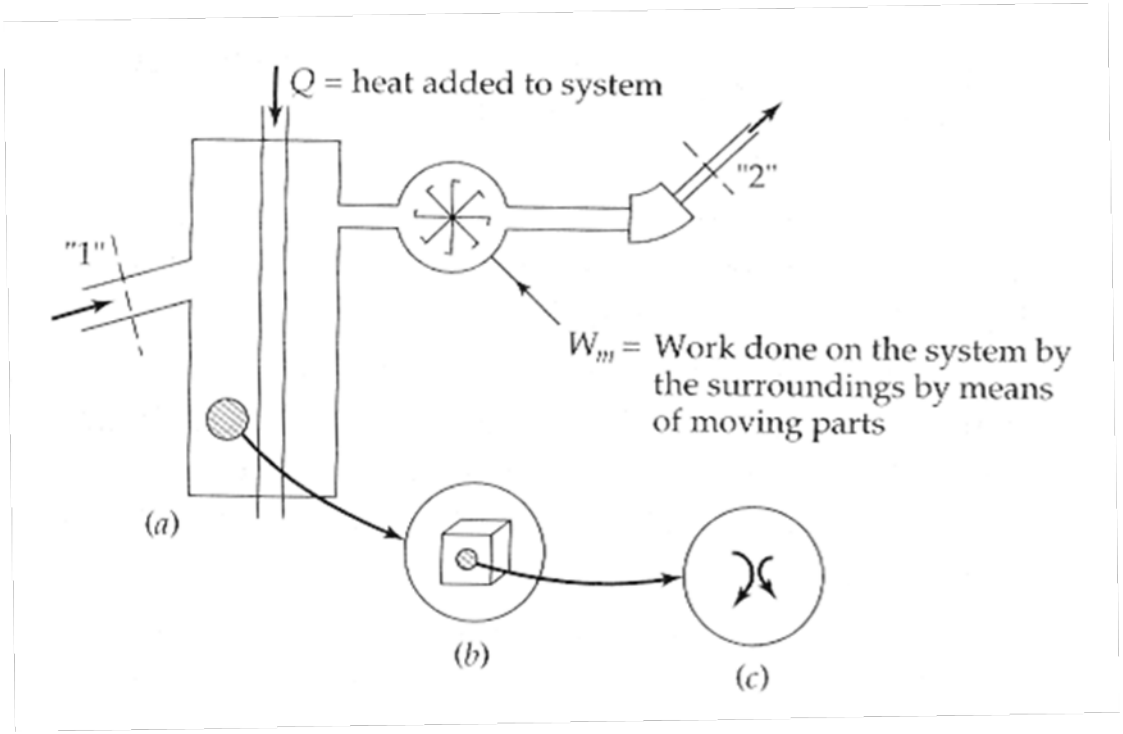
Three Levels at which Transport Phenomena can be Studied



Macroscopic: Write a set of equations (macroscopic balances) that describe how mass, momentum, energy and angular momentum in the system change because of the introduction and removal of these entities. No attempt is made to understand the details of the system.



Microscopic: We examine what is happening to the fluid mixture in a small region. We write a set of equations called "equations of change" which describe how mass, momentum, energy and angular momentum in the system change. The aim to get information about velocity, *T, p*, and concentration profiles within the system.



Molecular level: We seek a fundamental understanding of the mechanisms of how mass, momentum, energy and angular momentum in the system change in terms of molecular structure and intermolecular forces. Physicists and Chemists principal concern, but engineers in many cases need to gain this understanding.

Transport Phenomena

Second Edition

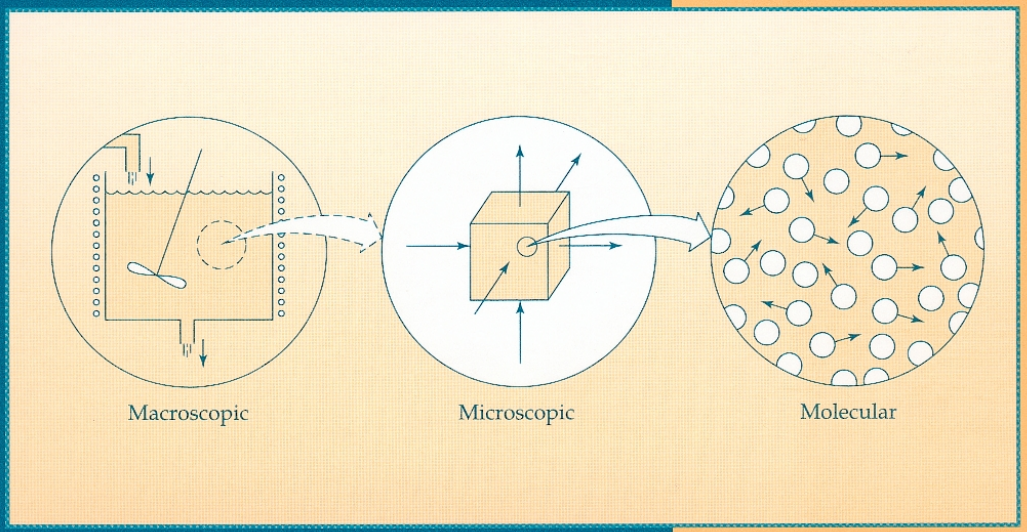


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Table 0.2-1 Organization of the Topics in This Book

Type of transport	Momentum	Energy	Mass
Transport by molecular motion	**1** Viscosity and the stress (momentum flux) tensor	**9** Thermal conductivity and the heat-flux vector	**17** Diffusivity and the mass-flux vectors
Transport in one dimension (shell-balance methods)	**2** Shell momentum balances and velocity distributions	**10** Shell energy balances and temperature distributions	**18** Shell mass balances and concentration distributions
Transport in arbitrary continua (use of general transport equations)	**3** Equations of change and their use [isothermal]	**11** Equations of change and their use [nonisothermal]	**19** Equations of change and their use [mixtures]
Transport with two independent variables (special methods)	**4** Momentum transport with two independent variables	**12** Energy transport with two independent variables	**20** Mass transport with two independent variables

Transport in turbulent flow, and eddy transport properties	**5** Turbulent momentum transport; eddy viscosity	**13** Turbulent energy transport; eddy thermal conductivity	**21** Turbulent mass transport; eddy diffusivity
Transport across phase boundaries	**6** Friction factors; use of empirical correlations	**14** Heat-transfer coefficients; use of empirical correlations	**22** Mass-transfer coefficients; use of empirical correlations
Transport in large systems, such as pieces of equipment or parts thereof	**7** Macroscopic balances [isothermal]	**15** Macroscopic balances [nonisothermal]	**22** Macroscopic balances [mixtures]
Transport by other mechanisms	**8** Momentum transport in polymeric liquids	**16** Energy transport by radiation	**24** Mass transport in multi-component systems; cross effects