Study Guide for CM3120 Transport II
Module 1 Prereq Material Unsteady Heat/Mass Xfer
Morrison Spring 2021

The test will cover material and system properties for heat transfer, macroscopic energy balances, heat calculations on liquids and gases, microscopic energy balances, transport laws, calculating engineering quantities of interest, dimensional analysis, calculations with data correlations, and the supporting mathematics.

<u>To do well on the test, you should be able to do the following:</u>

Material and system properties for heat transfer

1. Compare and contrast *thermal conductivity* and *heat capacity*
2. Define *heat transfer coefficient* and describe the engineering scenario in which heat transfer coefficient is a useful tool
3. Compare and contrast *thermal conductivity* k, *heat transfer coefficient* h, and *overall heat transfer coefficient* U
4. Distinguish between a *material* property or a *system* property in a momentum or heat transfer scenario
5. Compare and contrast *conduction*, *natural* and *forced convection*, and *radiation* heat transfer

Macroscopic open system mass and energy balances (reference, Felder and Rouseau)

6. Explain the individual terms of the macroscopic open system energy balance
7. Compare and contrast the macroscopic open system energy balance with the mechanical energy balance (MEB)
8. Perform and solve macroscopic open system mass and energy balances on elementary systems such as mixers, heat exchangers, separators, and distillation columns
9. Perform and solve MEB calculations for frictional losses, shaft work, pressure, or related quantities for systems including valves, fittings, turbines, and pumps

Heat calculations (liquids, gases, and saturated vapors)

10. Define the *dew point* and explain how to measure it
11. Define the *bubble point* and explain how to measure it; explain what systems it applies to
12. Compare and contrast *saturation* and *equilibrium*
13. Define *enthalpy* and describe its significance for calculating heat flow $\dot{Q}$ for flowing liquids and gasses
14. Calculate the heat required to raise the temperature of a gas or liquid stream by a certain amount (mass/molar flow rate or volumetric flow rate given)
15. Calculate the heat released when a certain amount of saturated vapor (for example, saturated steam) condenses, mass/molar rate of condensation given

Microscopic energy balances, transport laws, and engineering quantities of interest

16. Describe the transport laws for momentum and energy transport (give formulas and meaning of variables they include)
17. Simplify the microscopic energy balance for elementary scenarios (steady); arrive at a differential equation to solve for the temperature field
18. Identify and apply temperature boundary conditions for heat transfer scenarios

19. Identify and apply Newton's law of cooling boundary conditions (linear driving force heat transfer model) for heat transfer scenarios
20. Calculate temperature fields for elementary scenarios (steady)
21. Calculate engineering quantities of interest (flow rate Q, fluid force on a surface $\underline{\mathcal{F}}$, (stretch) fluid torque $\underline{\mathcal{T}}$) given pressure and stress fields

Dimensional Analysis in fluid mechanics and heat transfer (steady)

22. Explain the purpose of dimensional analysis
23. List dimensionless numbers that appear in the nondimensionalized microscopic mass balance (give formula and meaning, e.g. for which material)
24. List dimensionless numbers that appear in the nondimensionalized microscopic momentum balance for pipe flow (give formula and meaning, e.g. for which material)
25. List dimensionless numbers that appear in the nondimensionalized microscopic energy balance for forced convection (give formula and meaning, e.g. for which material)
26. (stretch) Contrast the momentum nondimensionalization for pipe flow and for flow around a sphere
27. List dimensionless numbers that result from nondimensionalizing engineering quantities of interest (flow rate Q, fluid force on a surface $\underline{\mathcal{F}}$, (stretch) fluid torque $\underline{\mathcal{T}}$)
28. Explain the meaning of *data correlation*; explain where we obtain data correlations
29. Provide an example of a data correlation used in fluid mechanics
30. Provide an example of a data correlation used in steady heat transfer

Complex flow scenarios. From material properties and geometry:

31. Predict pressure drop in turbulent pipe flow from flow rate
32. Predict volumetric flow rate Q in turbulent pipe flow from pressure drop
33. Predict pressure drop or flow rate Q for flow through packed beds
34. Predict heat loss $\dot{Q}$ in engineering scenarios involving forced convection, natural convection, and radiation

Mathematics through differential equations

35. Calculate two- and three-dimensional integrals of functions of up to three variables
36. Calculate partial derivatives of functions of more than one variable
37. Sketch a vector or vector field in a coordinate system
38. Identify limits of integration for quantities (for example, mass, volume, area) to be evaluated by 2D and 3D integrations in rectangular, cylindrical, and spherical coordinates
39. Calculate double (surface) and triple (volume) integrals with constant limits of integration in rectangular, cylindrical, and spherical coordinates

<u>*References:*</u>

- Richard Felder and Ronald Rouseau, *Elementary Principles of Chemical Processes*, 2nd Edition 1986
- Faith A. Morrison, *An Introduction to Fluid Mechanics*, 2013, Cambridge, NY
- Christie J. Geankoplis, *Transport Processes and Unit Operations*, 4th Edition, Prentice Hall, New York (2003)