Study Guide for CM3110
Module 1 Prereq Material for Fluids/Heat
Morrison Spring 2021

The test will cover process variables, elementary mass and energy balances, fluid statics/manometer problems, heat calculations for liquids, gases, and saturated vapors, and math prerequisites through differential equations (including vectors, vector fields, double and triple integrals, and partial derivatives).

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

Material and system properties for flow. Consider steady flow of an incompressible fluid of density ρ:

1. For flow through a pipe or noncircular conduit of constant cross section (pipe dimensions and shape known), calculate average velocity from a given volumetric flow rate.
2. For flow through a noncircular conduit of variable cross section (inlet cross section is A_1, outlet cross section is A_2), calculate the inlet and outlet average velocities from a given volumetric flow rate
3. Calculate volumetric flow rate from a given average velocity for all the cases above

Elementary macroscopic mass and energy balances (including mechanical energy balances, MEB, as covered in Felder and Rouseau)

4. Perform and solve macroscopic mass balances on elementary systems such as mixers, heat exchangers, separators, and distillation columns
5. List all the assumptions inherent in the MEB
6. Convert psia to psig and vice versa for a fluid pressure measurement P
7. Identify the correct pressure units (psia, psig, psi) for the pressure drop in a flowing liquid $\Delta p = p_1 - p_2$ for $p_1$and p_2 given in psig or psia
8. Interconvert metric (SI) and American Engineering units (lb_m, psi, etc) present in MEB calculations, especially the units of the terms $\Delta p/\rho$ and $g\Delta z$
9. Calculate the flow frictional losses in terms of the pressure drop in a horizontal pipe (diameter D, length L) with water flowing
10. Calculate pressures, average velocities, elevations, frictional terms, or shaft work for systems for which the MEB applies (within the scope covered by Felder and Rouseau)

Fluid statics/manometer problems

11. List the two simple rules that lead us to be able to solve any fluid statics/manometer problem
12. Calculate the pressure at the bottom of a column of a stationary fluid
13. Identify points in a static-fluid-containing apparatus that have the same pressures
14. Calculate static fluid pressure differences from manometer reading heights

15. Calculate static fluid pressure differences in an apparatus of complex shape with variable cross section
16. Calculate static fluid pressure differences in an apparatus containing several immiscible fluids of different densities

Heat calculations (liquids, gases, and saturated vapors)

17. Explain the difference between sensible heat and latent heat
18. Define enthalpy and describe its significance for calculating heat $\dot{Q}$ for flowing liquids and gasses
19. Calculate temperature difference $T_1 - T_2$ in units of both Celsius and Kelvin from two given temperatures
20. Calculate the heat required to raise the temperature of a liquid or gas stream by a certain amount (mass/molar flow rate or volumetric flow rate given)
21. Calculate the heat released when a certain amount of saturated vapor (for example, saturated steam) condenses, mass/molar rate of condensation given

Mathematics through differential equations

22. Calculate trigonometric functions (sine, cosine, tangent) in terms of the lengths of the sides of right triangles (SOHCAHTOA)
23. Decompose a vector into its components in a specified coordinate system
24. Calculate one-dimensional integrals and take derivatives of functions of one variable
25. Calculate partial derivatives of functions of more than one variable
26. Calculate a unit vector in the same direction of a given vector
27. Calculate the magnitude of a vector
28. Sketch a vector in a coordinate system
29. Sketch a vector field in a coordinate system
30. Calculate the dot product of a 1×3 vector and a 3×3 matrix representing quantities written in the same specified coordinate system
31. Calculate the dot product of a 3×3 matrix and a 3×1 vector representing quantities written in the same specified coordinate system
32. (stretch) Calculate the cross product of two vectors representing quantities written in the same specified coordinate system
33. 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
34. Calculate double (surface) and triple (volume) integrals with constant limits of integration in rectangular, cylindrical, and spherical coordinates

References:

- Richard Felder and Ronald Rouseau, *Elementary Principles of Chemical Processes*, 2nd Edition 1986. FAM notes
- 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). The Michigan Tech Library has an electronic version available; used copies are often available online for a reasonable cost.