CBE 320 Transport Phenomena
Spring 2008

Homework 10

DUE Friday, 4 April, 8:50 am
Read Ch. 10 (all sections), *BSL*

Note Exam 2 will be Tuesday, April 1, 5:00-7:00pm, 1227 Eng Hall. It will be closed-book, closed-note and cover through HW 9 and our 31 March class meeting.

1. Consider a brick with faces matched to the planes of the x-y-z coordinate systems. The brick, which has length L, width W, and depth D (into the paper), has a constant thermal conductivity k. Assume the upper and lower surfaces, at $z = 0$ and $z = L$, are set at the same temperature T_1. Further, the flux of energy as heat from the sides, at $y = 0$ and $y = W$, can be modeled by a simple expression $h(T - T_0)$, where h is a constant, T is the temperature at each surface, and $T_0 < T_1$. You may neglect any variations in the x-direction (into the paper).

Use the shell-balance approach to derive an equation that one would need to solve in order to determine the steady-state temperature distribution within the brick. The purpose of this problem is for you to show clearly how the shell-balance can be generated and used to derive the appropriate equation. (Note: derive but do not solve this equation).

2. Work Problem 10.B.2 Viscous heating in slit flow.

3. Work Problem 10.B.3 Heat conduction in a nuclear fuel rod assembly.

4. Work Problem 10.B.4 Heat conduction in an annulus. Hint for part (b): $\ln(1 + \varepsilon) = \varepsilon - 1/2\,\varepsilon^2 + 1/3\,\varepsilon^3 - \ldots$ (from Taylor series expansion). For ε small, we may approximate $\ln(1 + \varepsilon) \approx \varepsilon$.

Review Topics for Exam 2

Ch 3
1. Derivation of continuity (mass conservation), equation of motion (momentum conservation)
2. Given Navier-Stokes Eq, postulate velocity components for different geometry/flow examples, simplify NS equations, solve for velocity distributions.
3. Eq. of mech energy
4. Dimensional analysis

Ch4
4. Note that non-steady state problems make velocity distributions dependent on not only position, but also time

over →

Ch5
5. laminar/turbulent flow
6. time-smoothed eq. of change
7. turbulent mom flux

Ch 6
8. Definition of friction factor (f)
9. f for tube flow, definition, and derivation of f = f(Re)
10. f vs Re plot, circular and non-circular tubes
11. f for spheres/particles, f vs Re

Ch7
12. macroscopic momentum balance
13. macroscopic mechanical energy balance, Bernoulli Eq.
14. Derivation and application of friction losses (Ev) for tubes, fittings

Ch 9
15. heat transfer by conduction (Fourier's Law), analogy to momentum transfer
16. thermal conductivity (T, P dependence)
17. convective energy transport (combined energy flux vector)

Ch10
18. Energy Shell Balances (for conduction)
19. Newton's law of cooling (heat transfer cofficient)
20. Viscous heating, Brinkman number