CBE 320 Transport Phenomena
Spring 2008

Homework 4

DUE	Friday, 15 February, 8:50 am
Review	Chapter 2 (all sections) *BSL*
Read and digest	Chapter 3 (all sections except 3.4) *BSL*

Please Use only one side of your sheets (recycled paper okay), draw a box around your answers, and staple all your pages together.

Note Exam 1 will be Tuesday, February 19, 5:00-7:00pm, location to be announced. The exam will be closed-book, closed-note and cover material through HW 4 and our February 18 class meeting.

1. Solve **Problem 2A.3**. Volume flow rate through an annulus.

2. Solve **Problem 2B.6.** Flow of a film on the outside of a circular tube.

3. Solve **Problem 2B.7** (parts a-c). Annular flow with inner cylinder moving axially.

4. **Water flow through nanotubes.** Developments in nanotechnology have demonstrated the feasibility of creating 'nano-scale' pores in membranes that are 1-2 nm in diameter. For a recent example see, "Fast mass transport through sub-2-nanometer carbon nanotubes." Holt JK, et al. *Science*. 2006 May 19; 312(5776):1034-7. Refer to this article to answer the following questions:

(a) Describe in simple terms, using 2 or 3 complete sentences what is a "nanotube-based membrane," and what advantages might such membranes have over conventional membranes.
(b) Table 1 refers to a size-exclusion test that used different analytes to characterize molecular fluxes through different "DWNT" and "MWNT" membranes. For a common scale, draw a representative pore of a DWNT membrane, the molecular structure of the smallest analyte, $Ru^{2+}(bipyr)_3$, and a single water molecule.
(c) The article employs a "continuum flow model" to predict how water should behave as it flows through nanopores. Describe, in 3 to 5 sentences, the key assumption(s) of this model that causes the model to fail in its prediction for water flow through nanopores.