

CBE 320 Transport Phenomena

Spring 2008

Note Exam 1 will be Tuesday, February 19, 5:00-7:00pm, in 1227 Engineering Hall.
The exam will be closed-book, closed-note and cover material through HW 4 and
our February 18 class meeting.

Topics for Exam 1

Chapter 1 (BSL, 2nd Ed)

1. Newton's law of viscosity
2. Generalization of Newton's law
3. Viscosity dependence on T, P
4. Convective momentum transport

Ch 2

5. Shell balances for momentum conservation and boundary conditions
6. Examples: falling film, circular tube, annulus, flow around a sphere

Ch 3

7. Derivation of continuity (mass conservation), equation of motion (momentum conservation)
 8. Given Navier-Stokes Eq, postulate velocity components for different geometry/flow examples, simplify NS equations, solve for velocity distributions.
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Homework 5

DUE Friday, 22 February, 8:50 am
Review Chapter 3 (all sections except 3.4) *BSL*

1. Solve **Problem 2A.4**. Loss of catalyst particles in stack gas.
2. Estimate the value of the Reynolds number for (i) a large whale swimming at 10 m/s, (ii) a duck flying at 20 m/s, and (iii) a bacterium swimming at 0.01 mm/s.

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3. A spherical particle settling in a large vat of honey may experience a number of forces. In the upward direction it experiences the following force:

$$F_{upward} = \frac{4}{3}\pi R^3 \rho g + 6\pi\mu Rv_{\infty}$$

(a) Derive an expression for the terminal velocity of the particle, expressed in terms of particle and honey properties. Make sure you clearly define all terms in your final expression and check that it has the correct dimensions.

(b) The above analysis assumes (indicate the best answer):

- (i) the particle Reynolds number is less than 0.1
- (ii) the particle Reynolds number is less than 2100
- (iii) upward and downward forces on the particle are equal in magnitude
- (iv) downward force on the particle is greater than upward force
- (v) answers (i) and (iii)
- (vi) answers (i) and (iv)
- (vii) answers (ii) and (iii)
- (viii) answers (ii) and (iv)

[This is an old exam problem.]

4. **Microfluidic systems.** The design, analysis and optimization of flow systems are increasingly performed at the microscale (10^{-6} m). Use the current technical literature (or consult your favorite reference librarian for help) to address the following:

- (a) Identify and clearly describe three to five advantages of microscale systems over human scale (about 1 m) systems.
- (b) Find names of two or three companies that are engineering microscale systems that involve fluid (liquid) flow, and briefly describe in what fields these systems will be used.
- (c) What is the largest Reynolds Number (Re) you can find for a microscale system? (Search in the technical literature for at least three papers where a Re is determined.) Show how its value of Re may be calculated or estimated, based on a definition of Reynolds number for the flow geometry of interest, the fluid properties, and the operating conditions.