

## Homework 6

DUE Friday, 29 February, 8:50 am  
Read Chapter 4 (only section 4.1), Chapter 5 (sections 1-4) *BSL*

1. Review of Exam 1. This exercise aims to help you learn from errors or problems that may have arisen during exam 1. It applies to every problem for which you did not receive full credit.
  - (a) If you lost points due to a mathematical error, explain what the error was and suggest a strategy to help you avoid similar errors in the future.
  - (b) If you lost full credit for other reasons, then solve the full problem here. If you are unable to get a start on the solution, study the solution key. Then, without referring to the solution key, re-read the problem and solve it on your own. DO NOT simply copy the solution from the key or you defeat the purpose of this exercise.

All reworked exam solutions (parts a and b) should accompany your Homework 6. After completing this exercise you should be able to re-take Exam 1 and achieve a perfect score.

2. Write the equation of continuity and equation of motion in dimensionless form. Assume you have a Newtonian fluid with constant density and viscosity, and use the following definitions of dimensionless variables (note that dimensionless pressure is different from the form presented in class):

$$\mathbf{v}^* = \frac{1}{V} \mathbf{v} \quad \mathbf{x}^* = \frac{1}{D} \mathbf{x} \quad t^* = \frac{V}{D} t$$
$$p^* = \frac{P - P_0}{\mu V / D} \quad \nabla^* = D \nabla$$

where  $D$  and  $V$  are characteristic length and velocity scales, respectively. You should obtain the following dimensionless equations:

$$\nabla^* \cdot \mathbf{v}^* = 0$$
$$\text{Re} \left[ \frac{\partial \mathbf{v}^*}{\partial t^*} + \mathbf{v}^* \cdot \nabla^* \mathbf{v}^* \right] = -\nabla^* p^* + \nabla^{*2} \mathbf{v}^* + \frac{\text{Re}}{\text{Fr}} \mathbf{g}$$

where  $\text{Re}$  and  $\text{Fr}$  are the Reynolds and Froude numbers, respectively.

3. Solve Problem 2B.11 Cone-and-plate viscometer. (Note: we encountered a similar problem in class). You may use the general equations of motion provided in Appendix B of *BSL*.
4. Solve Problem 3B.5 Parallel-disk viscometer.
5. Solve Problem 4A.1 Time for attainment of steady flow in tube flow.