Ph.D. Qualifying Examination
Fluid Mechanics-Closed Book
Fall 2009

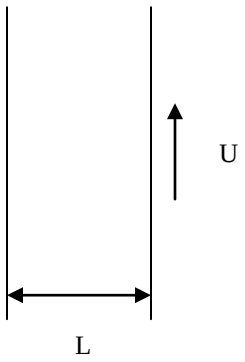
Identification Number: _____
(Please also indicate your identification number on subsequent pages.)

Instructions: Two hours are allotted for the exam. All problems must be performed within the space provided. Use the back of sheets if necessary. Do not unstaple or add pages to the exam.

Point values for each problem are indicated below. Only fundamental concepts and equations are required for each problem. An equation sheet is therefore not provided. All parameters and symbols that you introduce should be defined. Clearly state your assumptions in all problems.

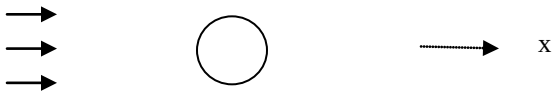
Problem 1:	25 pts.
Problem 2:	25 pts.
Problem 3	25 pts.
Problem 4	25 pts.
Total Points =	100

1. Fluid with a viscosity ν flows vertically between two parallel walls, one at rest and the other moving at a velocity U. The distance between the walls is L. Determine the velocity U at which the net flow rate between the walls is zero.



2. A uniform flow of strength U_∞ approaches a 2-D cylinder of radius R. The velocity distribution at a flow cross section downstream of the cylinder is described by:

$u(y) = U_\infty(y/2R)^2$ for $0 \le y \le 4R$ where R = radius
$u(y) = U_\infty(-y/2R)^2$ for $0 \ge y \ge -4R$
$u(y) = U_\infty$ elsewhere



where y is the direction normal to the oncoming flow. Using the control volume equations of motion, estimate the drag per unit span on the cylinder. Please state any and all assumptions used and show how they are used to solve the problem.

3. The x- and y-components of a two-dimensional, steady and incompressible flow are given by

$$u = 2y$$
$$v = 4x$$

Determine the steam function of this flow field and sketch a few streamlines.

4. A thin square plate (side width: *d*) is placed in a pipe of diameter D as shown below. The drag force F_d acting on the plate is a function of its side width *d*, pipe diameter *D*, fluid velocity *V*, and fluid density ρ.

(1) Determine the appropriate dimensionless groups for this problem.

(2) An experiment was performed using water as working fluid, and found that the drag force is 0.0015 lb when d = 0.2in, D = 0.5in, and V = 2 ft/s. Can this data be used to predict the drag on a square plate of 0.2 ft width in a 0.5 ft pipe carrying water at a speed of 4 ft/s? If yes, compute the value of the drag force; if not, explain why.