Ph.D. Qualifying Examination

Fluid Mechanics

Spring 2011

Notes:

- Time allowed: 2.5 hours.
- Part 1 of exam (20%) is closed book and closed-notes, no calculator (turn it in before beginning work on part 2)
- Part 2 of exam (80%) is open book, open notes, calculator allowed, and 1 textbook allowed.
- State your assumptions, methods, and procedures. Show your work on these exam sheets. (Add additional sheets, if needed.)
- Laptops and cell phones are not allowed.

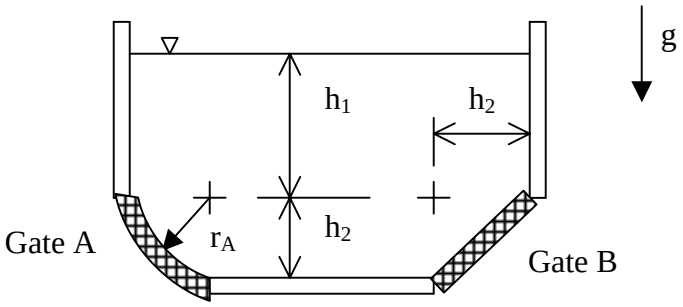
Fluids Sp 2011 **Part 1** (20%) **closed book and closed-notes, no calculator**

1. What is the difference between Newtonian and non-Newtonian fluids? Give an example of each.

2. What is the no-slip boundary condition? Give its mathematical formulation and explain its physical meaning. Between what surfaces this condition is applied?

Continued: Fluids Sp 2011 **Part 1** (20%) **closed book and closed-notes, no calculator**

3. Consider 2 gates submerged in a liquid as shown. Explain carefully whether gate A or B experiences the greater hydrostatic force. Use one unit length into paper; note that $r_A=h_2$.



4. Define:

a) Cavitation

b) center of pressure (in hydrostatic problems)

c) Reynolds number

Fluids Sp 2011 **Part 2** (80%) **open book (1 textbook), open notes, calculator allowed**

1. The stream function for a two-dimensional, inviscous, incompressible flow field is given by the expression

$$\varphi = 4xy^2 - \frac{4}{3}x^3$$

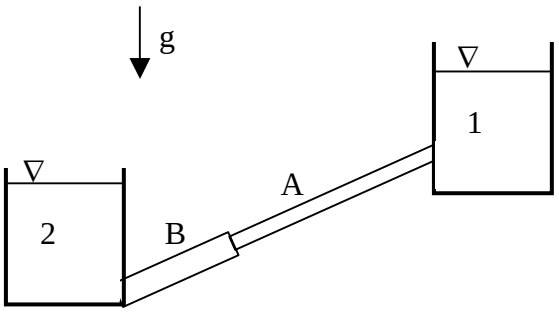
(a) Is the continuity equation satisfied?

(b) Is the flow field irrotational? If so, determine the corresponding velocity potential.

(c) Determine the pressure gradient in the horizontal *x* direction at the point: *x* = 0 *m*, *y* = *2 m*.

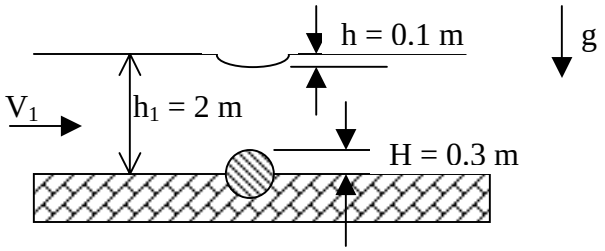
Fluids Sp 2011 **Part 2** (80%) **open book (1 textbook), open notes, calculator allowed**

2. Two reservoirs are connected by 200 ft of commercial steel pipe (D_A=2 in.) and 20 ft of cast iron pipe (D_B=3 in.) with square-edged entrance and exit and sudden expansion from pipe A to pipe B. For pipe B only, use $(fL/D)_B$=8 (fixed). Compute the flow rate (gpm) of water at 60°F if the level of reservoir 1 is 40 ft higher than that of reservoir 2. *One iteration for friction factor* f_A *is sufficient.* List all values of friction factor, Reynolds number, roughness ratio, and velocity used.



Fluids Sp 2011 **Part 2** (80%) **open book (1 textbook), open notes, calculator allowed**

3. At low velocity, a hump on the bottom of a water channel causes a dip in the water surface that can be used to determine the flow rate. For the conditions shown, what is flow velocity V_1? Take the flow to be two-dimensional, that is, the hump and dip extend across the width of the channel.



Fluids, cont. Problem _____