CE100
Final Examination
Fall, 2007
December 13, 2007

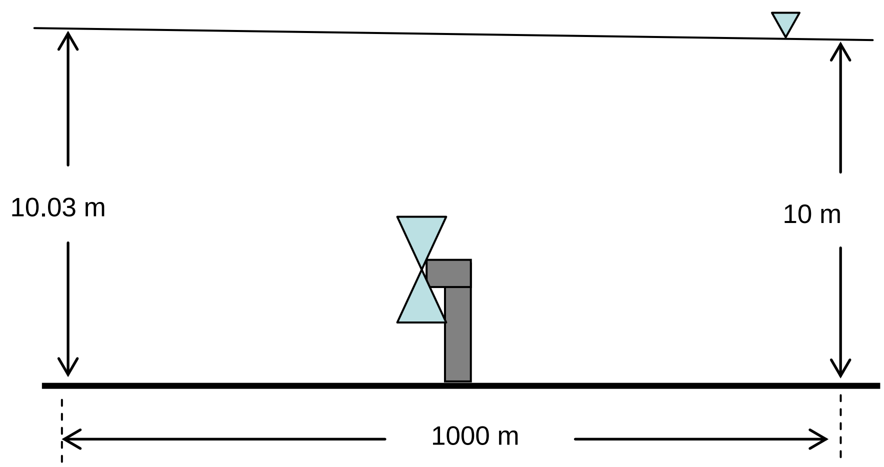
Name ____

Student I.D. _______________________

This exam is open book and open notes. You will be given three hours to complete four problems. Space is provided on each page for your solution, the back of the pages may also be used. Additional scratch paper is available if needed. State clearly any assumptions you use in the solutions. Good Luck!

Problem 1 (40 points):

Tidal power extraction is being viewed as a potential source of renewable energy. There are a variety of mechanisms for extracting tidal power; the simplest to picture is a "windmill" (turbine) beneath the water, as shown in the figure below (flow is from left to right).



The depths of the flow are as shown at a distance of 500 meters upstream and downstream of the turbine. The average velocity through the upstream measurement location is 1 m/s. The width of the channel is 1000 meters, and the shear stress on the bottom of the channel is uniform and is $\tau = 2.85\ \mathrm{N/m^2}$. For this set of measurements, define:

(1) The force that the "windmill" exerts on the fluid. You may assume that the velocity is uniform over the entire cross-section.

(2) From that force, calculate an effective drag coefficient for the windmill. You may assume the frontal area of the windmill is $25\ \mathrm{m^2}$.

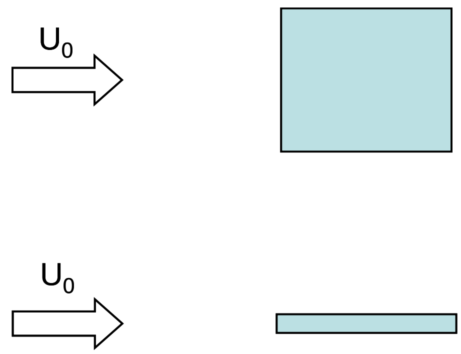
Problem 2 (40 points):

Levee failures in New Orleans during Katrina were largely attributed to hydrostatic forces. In this problem we consider the forces experienced by the sidewall levees on a rectangular channel. If the channel slope is $S0 = 0.0005$, Manning's n is $n = .1$, the flowrate is $Q = 1600\ m^3/s$ and the channel is rectangular with a width of $W = 500$ m, calculate the following:

(1) Assuming the channel is infinitely long and uniform, what is the depth of flow in the channel? You may assume that the channel width is much greater than the depth for purposes of calculating the hydraulic radius.
(2) Is the flow calculated in (1) subcritical or supercritical?
(3) For the flow in (1), calculate the lateral hydrostatic force on one side wall of the channel for a segment of levee wall that is 10 meters long in the along-channel direction.
(4) Suppose now that the flow calculated in (1) encounters a constriction of the channel to a width of $W = 400$ m. Will the hydrostatic force on the side walls in the constriction be greater or less than those calculated in (3)? Use a specific energy diagram to justify your answer.

Problem 3 (10 points):

Consider the following shapes sitting in a cross-flowing fluid (with velocity U_0):



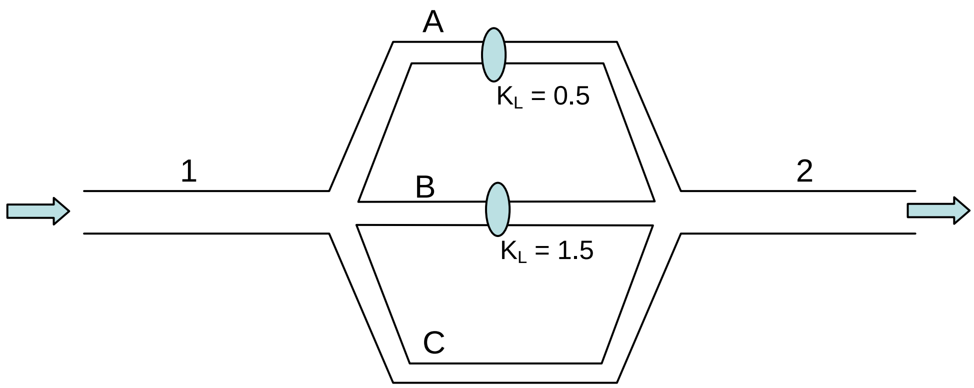
Both shapes have the same plan form area (into the page and in the flow direction), the only difference is in the thickness (as shown). For this case:

(1) Considering only the contribution of the tangential shear stress along the surface of the object, which shape will experience a larger drag force. Why?

(2) Which shape will experience the larger total drag force. Why?

Problem 4 (10 points):

A portion of a pipe network is constructed as:



Although the diagram doesn't reflect this, you may assume that segments (A, B and C) are all the same length. Further, assuming that all pipes are the same diameter, and are made from the same material (i.e., have the same roughness):

(1) Which of the parallel pipe segment (A, B or C) will have the largest velocity? Which will have the smallest? Why?
(2) Which of the two pipe segments that are in series (1 or 2) will have the larger velocity? Why?