

2.011 Take home exam; Spring 2006

Out: Friday May 5th

Due: Friday May 12th; by 5pm

Hand into TA or electronically via email.

Make sure your name is on all submissions!

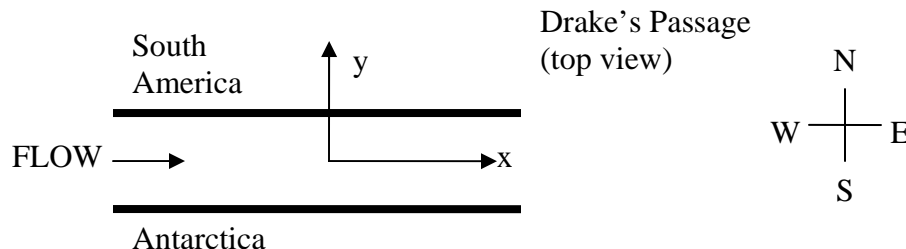
Problem 1:

You are hired by a consortium of oceanographic agencies to investigate the Antarctic Circumpolar Current (ACC). From your basic knowledge of the ocean you know very little about the ACC, but you do remember hearing once that it is a region of very high wind and waves and that the current travels all the way around the continent of Antarctica.

- Before you can start your project you need to do a little background research. *In approximately one page*, describe the ACC and its significance on global ocean circulation and weather, and transport of things like nutrients, fish, phytoplankton, etc. What are the general weather and water column properties in the current (e.g. waves, wind, temperatures, salinity, current velocities...)? What is the predominant force driving this current? Web pages are acceptable sources – but cite your sources!
- From your research you may have read that the majority of water in the ACC passes through Drake's passage at the southern tip of South America. You can roughly model this passage as a rectangular channel (see sketch below) and a current flowing to the east (positive x-direction, clockwise around Antarctica). You can assume that this current does not vary with depth down to about half of the channel depth; below this you can assume there is no flow. Neglect Coriolis force in parts b and c only and neglect wind generated waves for parts b-d.

*Using the basic governing equations for fluids and relevant boundary conditions, determine the **velocity profile** across the channel from North to South (positive y-direction is considered to point northward, positive z-direction is taken up from the free surface).*

You can assume that this is steady, fully-developed flow (i.e. it's been flowing through the channel for a long time and the profile hasn't changed in time). You can assume that the walls are vertical and that the channel can be considered infinite in length. To start consider only a simple section looking down on the channel, and neglect the effect of depth on the flow. Assume that the pressure gradient in x-direction, along the channel, is constant.



Hint: flow across this channel (N-S) is symmetric!

- c) Using the profile from part b, determine an approximate **volume flow rate** through the channel in terms of the constant pressure gradient in the x -direction. You can assume a specific channel depth taken from literature compared with the channel's width, or leave this in terms of general variables. Assume, still, that the flow does not vary with depth down to half the channel depth.
- d) The ACC loops around Antarctica and is driven primarily by wind. This wind creates an Ekman Layer and results in Ekman pumping. Locally, the continent can be loosely modeled as a straight shoreline with a vertical wall dropping off to the deep ocean. Assuming the wind is a westerly wind (blowing out of the west to the east). *Determine the direction of Ekman Pumping and calculate the Ekman Mass transport in the x and y directions for a wind velocity $U_{10} = 2 \text{ m/s}$. Use a reasonable estimate for $C_d \sim 0.003$.*

Problem 2:

In at least two (2) typed pages (~double spaced, 12point, 1in margins) detail *your* contributions to the 2.011 Mega SeaPerch Vehicle. Detailed specifications and or photos can be added, but text should be equivalent of about 2 pages.

- This discussion can include both your part in the building of the basic ROV and your specific “advanced” instrument.
- Describe what your goal was (e.g. to build an instrument to measure x , why is x important in the ocean?); your approach to the problem (e.g. modified existing sensor or built from scratch using x , y , z parts; include basic schematics, or sketches, where appropriate); and any recommendations for future modifications/improvements.
- Discuss calibration issues where necessary or problems that you anticipate might arise in testing.
- Discuss what you learned in the process of building your apparatus.

Just for fun:

Name our ROV.

The END.