13.00 Introduction to Ocean Science and Technology
Problem set 5

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1. The Southern Ocean (surrounding the Antarctic Continent) is normally driven by strong winds from West to East (clockwise around Antarctica). Describe and show in sketches:

- the direction of the Ekman transport
- the effect of the Antarctic Continent on the Ekman motion, the sea-surface slope, and the pressure;
- the influence of the Ekman transport on the N-S density gradient;
- the resulting geostrophic flow in the near-surface water.

Do not (re)derive fundamental relationships that are discussed in detail in the lecture notes. For example, do not repeat the Ekman analysis here, but be sure to explain how the general conclusions of the Ekman analysis lead to certain conclusions in your sketch(es) — and similarly for the other parts of the question. You will need to present two figures, (i) a map (plan) view of a sector of the Antarctic/Southern Ocean area and (ii) a vertical cross-section of the ocean near the Antarctic Continent. You should show and explain features such as upwelling, downwelling, convergence, and divergence *(if they occur)*. Where is the water relatively cold or warm and how does that affect the pressure gradient, slope, etc.?

2. Show that the flow field given by:

$$\text{(a)} \quad u = \frac{-Cy}{x^2+y^2}, \quad v = \frac{Cx}{x^2+y^2}, \quad w = 0;$$

is irrotational and that it has a velocity potential given by:

$$\phi(x,y) = C\tan^{-1}(\frac{y}{x}).$$

3. Define a 2-D flow,

$$u = -Ey, v = Ex, w = 0.$$

Is this flow irrotational? Draw a "close-up view" showing what happens to a square of fluid. How might you generate such a motion in reality?

4. A ship 140 meters long steams at a velocity V in deep water into a series of approaching waves. It is noticed that successive wave crests pass under the bow at intervals of 6 seconds and that the wavelength is just equal to the length of the ship. What is the velocity V in meters per second?