SIO 210 Introduction to Physical Oceanography
Mid-term examination
Friday, November 9, 2007
2:00 – 2:50 PM

This is a closed book exam. Calculators are allowed but might not be necessary. (100 total points.)

1. The horizontal momentum equations in the east-west direction can be expressed as

acceleration + advection + Coriolis = pressure gradient force + viscous terms
(1) (2) (3) (4) (5)

Which terms balance for each of the following processes? (You can just list the number of the term if you want.)

(a) Geostrophic flow _____ and _____

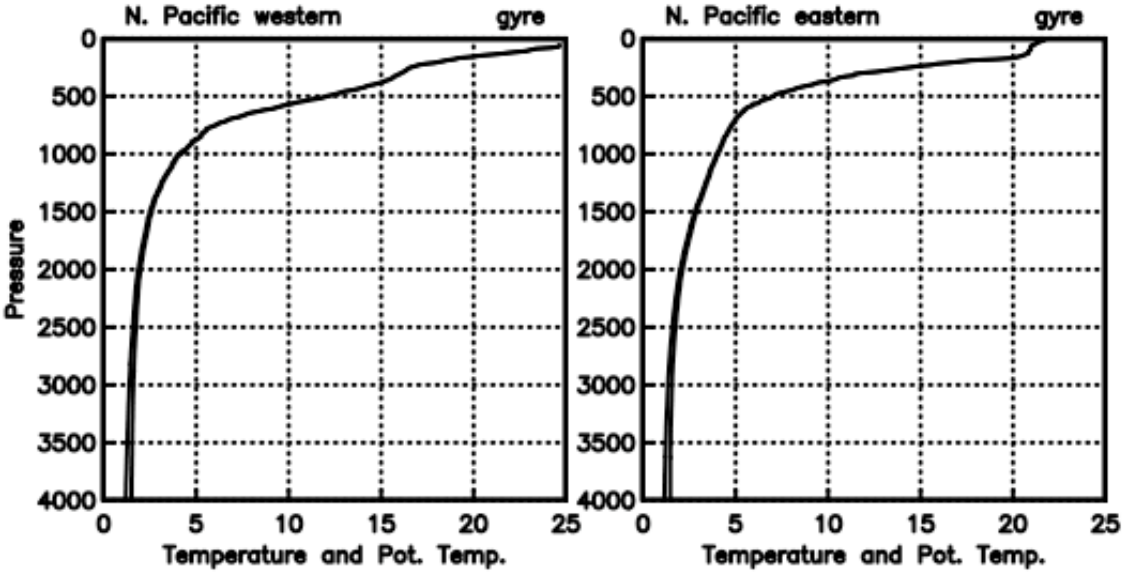
(b) Ekman layer _____ and _____

(c) Inertial motion _____ and _____

2. The vertical momentum equation is similar to the momentum equation given in Problem 1. What additional term is needed for the vertical momentum balance? (Please ignore tides.)

3. (a) Explain briefly what potential temperature is. Assume that it is calculated relative to the sea surface.

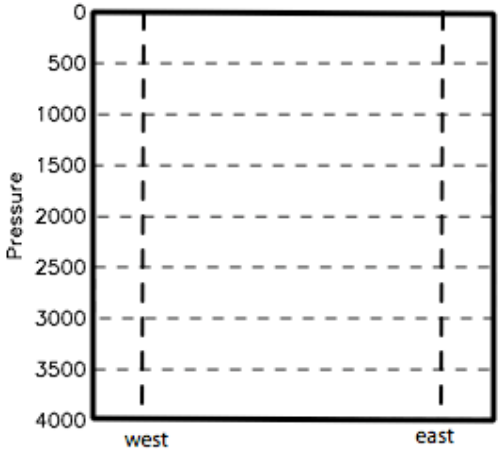
(b) The plots show temperature and potential temperature profiles at two different locations in the North Pacific. On each plot, indicate which curve is temperature and which is potential temperature.



(c) On the plots above, indicate where the thermocline is found.

(d) On the plots above, indicate where there is a thermostad.

(e) Construct a very simple "vertical section" from these two profiles. That is, in the following box, make a vertical section of potential temperature.



(f) Assume that potential density contours look just like potential temperature contours. On the plot in (e) indicate the *direction of geostrophic flow* at the sea surface if it is zero at the bottom.
(Please do not calculate anything.)

(g) Based on your answer in (f), do you think these profiles are from the subtropical or the subpolar gyre in the North Pacific? Why? (You can check this against what you know about temperature ranges for the subtropics and subpolar region.)

(g) Above the plot in (e), sketch the sea surface based on your result for (f).

(h) For your sketch for (g), indicate <u>very roughly</u> what the relative height of the sea surface is at one location compared with another. Assume that these stations are typical of the North Pacific's gyre.
(I am not interested in an exact number, but I do want the order of magnitude to be correct in comparison with the isothermal depth variations.)

4. The acceleration term is ignored in geostrophic balance. This is because which of the following non-dimensional parameters is small?

Circle the correct answer:

Ekman number $\nu U/fL^2$

Rossby number $1/fT$

Reynolds number UL/ν

5. This is a map of steric height at 4000 db in the South Atlantic. Assume that the units are essentially in meters.

(a) Locate and mark the high pressure regions on the map.

(b) Locate and mark a cyclonic circulation cell on the map.

(c) At 35°S in the western basin (near coast of South America), there is a set of closely-spaced contours, marking a deep western boundary current flowing northward. What is the difference in steric height from west to east across this set of contours?_____

(d) Contrast the answer to (c) with what you know about the difference in steric height at the sea surface across the Gulf Stream.

(e) Estimate the flow speed for the South American deep western boundary current. Assume that 1 degree of longitude is equal to about 100 km, and use what you know about Gulf Stream surface velocity and Gulf Stream width to help you estimate the velocities for this deep boundary current.

(f) What is the source of water for the deep western South Atlantic?