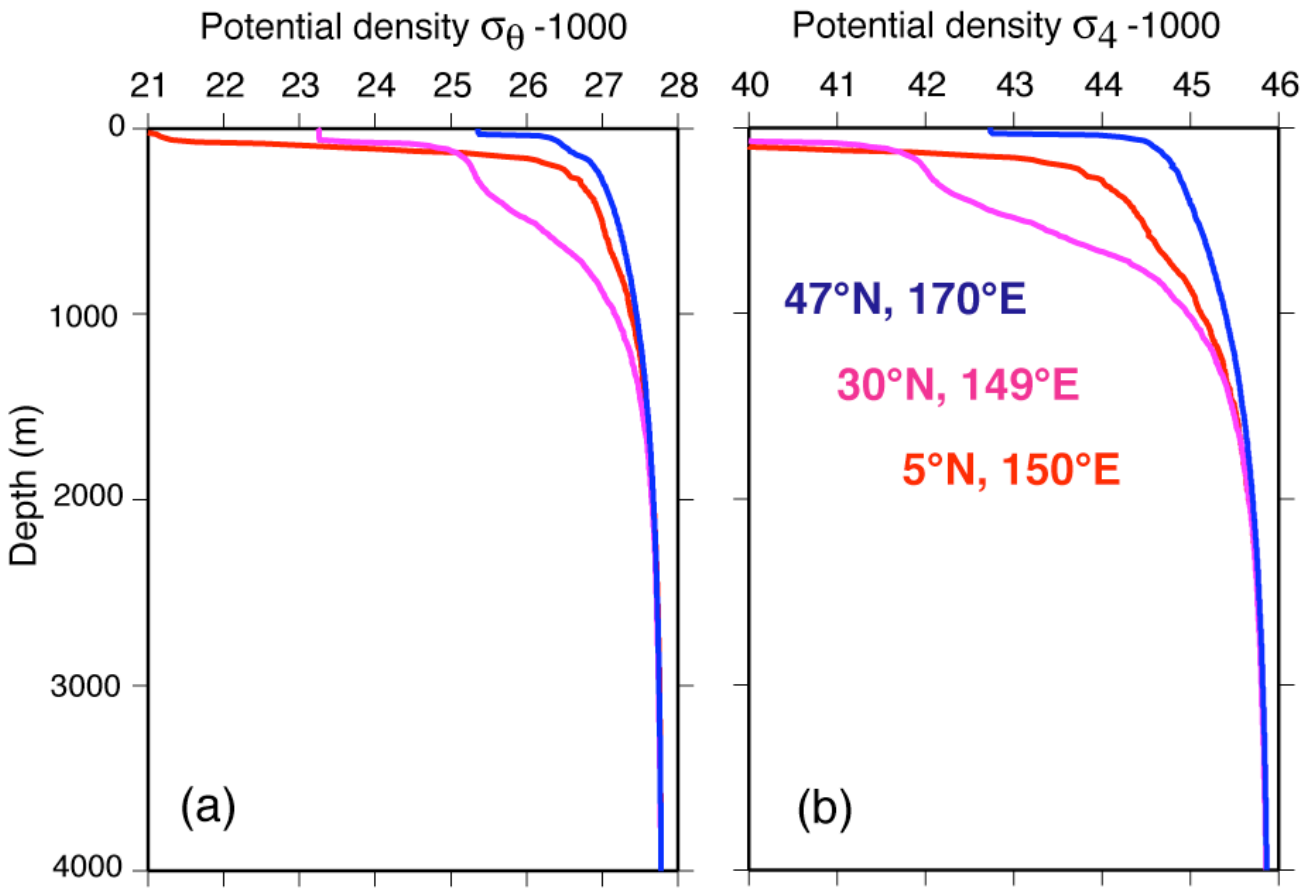
SIO 210 Introduction to Physical Oceanography
Mid-term examination
Monday, October 30, 2006
2:00 – 2:50 PM

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

1. The figure shows two types of potential density at locations in the North Pacific. The same stations are used on both plots.
(a) Define potential density. What are its units?

(questions continued after figure)



(Problem 1 continued)

(b) What is the difference between the way that one calculates the potential density plotted in the left panel and the potential density plotted in the right panel?

(c) Explain the different sizes of the values in the two panels. (Why are they different and why are values in the right panel larger than in the left?)

(d) Look at the difference in the two potential densities between the purple and blue profiles at about 200 meters depth. Which is larger? Explain.

Define and then locate an example on the figure:

(e) mixed layer: _____

(f) pycnocline: _____

(g) pycnostad: _____

2. The Rossby number is a non-dimensional parameter that is associated with the importance of rotation.

Using this simplified equation of motion for one of the horizontal directions:

acceleration + Coriolis = forces (2.1)

$\partial u/\partial t - fv =$ forces (2.2)

where $f = 2\Omega \sin(\text{latitude})$ and $\Omega = 0.73 \times 10^{-4}$ sec^{-1}
Assume that latitude = 30° so that sin(latitude) = 0.5.

The Rossby number allows us to compare the sizes of the two terms on the left-hand side with each other.

In order to compare these two terms, you have to choose a velocity scale and a time scale. Assume that the velocity scales for u and v (in the two horizontal directions) are the same.

(a) In symbols only, what is the ratio of the size of the acceleration term to the Coriolis term? (Use 2.2) (This is the Rossby number. As a check on your work, it should have no units).

Choose reasonable velocity and time scales for the following and calculate an approximate Rossby number:

(b) surface wave

(c) Gulf Stream

(d) Atmosphere's storms

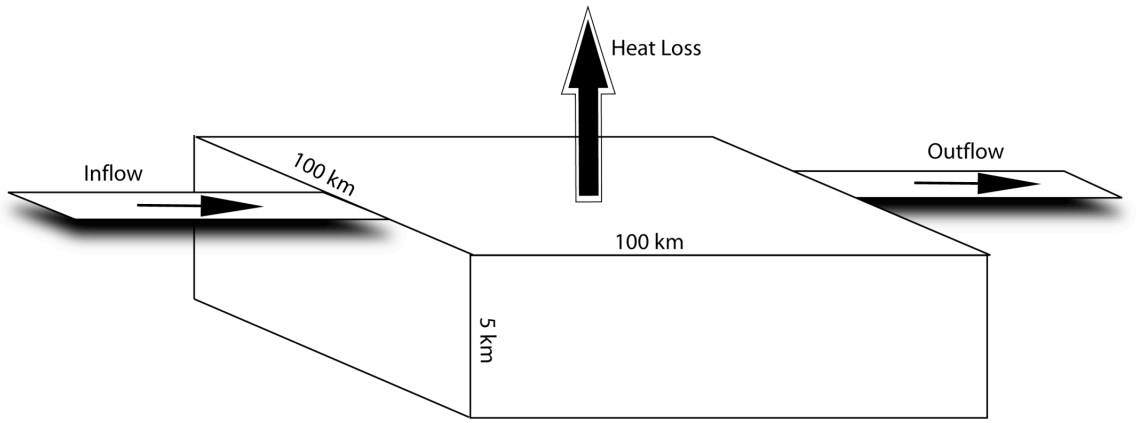
3. Water flows into and out of a box, shown in the figure.

(a) What are the units of the total *mass* transport INTO the box?

(b) If the average velocity of the water into that side of the box is 5 cm/sec, calculate the mass transport using the dimensions shown in the figure and a reasonable single value for density.

(c) If you know the mass transport into the box, what can you say about the mass transport out of the box?

(d) If the arrow at the top represents evaporation – precipitation, and the direction of the arrow means that there is net evaporation, is the salinity of the outflow larger or smaller than the salinity of the inflow? (no calculation)

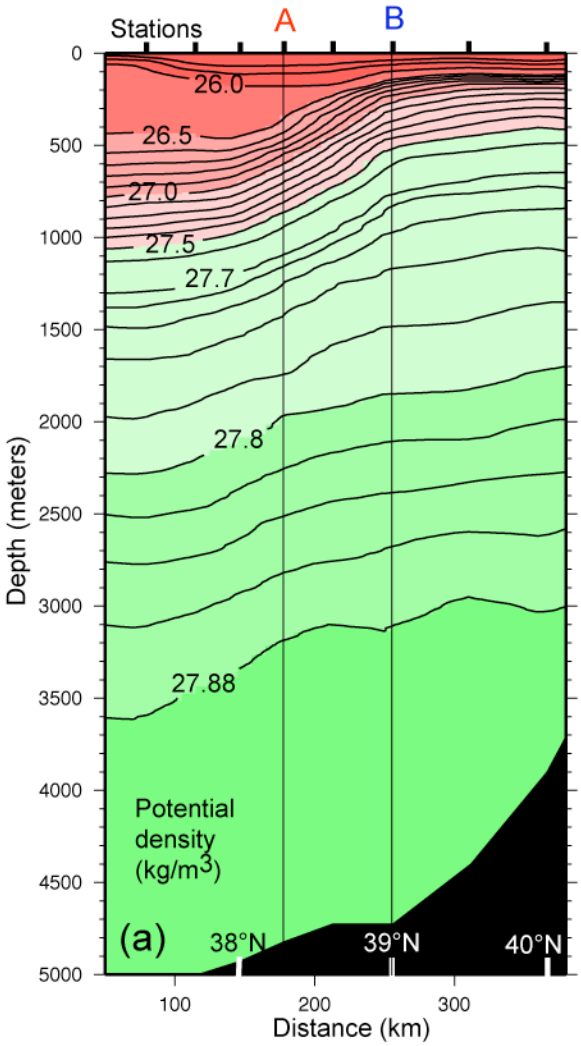


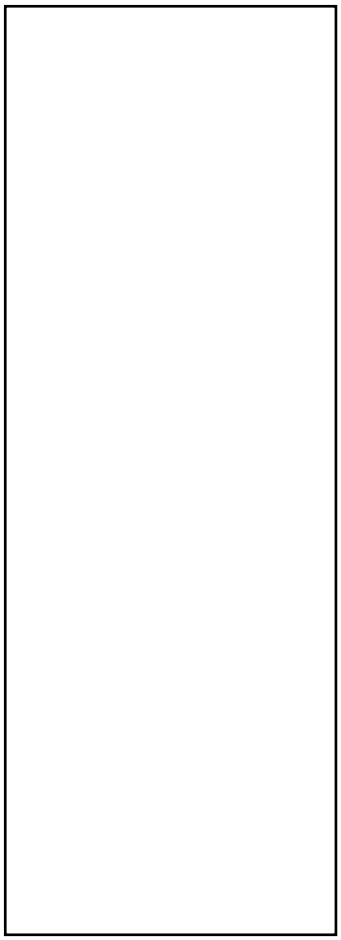
4. The left figure is potential density relative to the sea surface at a location in the North Atlantic.

(a) Indicate on the figure where you expect to find the strongest current (in both the distance and depth coordinates).

(b) Sketch the most likely distribution of sea surface height just above the section.

(questions continued below the figure)





(Problem 4 continued)

(c) Indicate on the figure the most likely direction of the current between A and B at 1000 m depth.

(d) What is the relative strength of the current at 1000 m compared with the strongest current you indicated for (a)? (SHORT ANSWER – please do not calculate anything and don't explain – see part f below) _____

(e) In the blank panel to the right, sketch the vertical profiles of potential density at both A and B.

(f) Use the difference in density between A and B to explain the answer to (d).

SIO 210 Fall 2006, Final questions on waves and tides. (Hendershott)

There are all multiple choice questions, please answer by circling the letter next to the most nearly correct answer or writing the correct letter in the blank space provided.

TIDES. (i), (ii) easy; (iii), (iv) novel

(i) At most open ocean ports the time interval from one high tide to the very next high tide is most nearly

a. 12 hours,
b. 12 hours 25 minutes,
c. 11 hours 35 minutes,
d. 24 hours,
e. 24 hours 25 minutes,
e. 23 hours 35 minutes.

(ii) At ports where the tide is nearly entirely diurnal, the tidal range nearly vanishes

a. at new or full moon,
b. at the quarter moons,
c. when the moon passes through the earth's equatorial plane,
d. when the moon is farthest out of the earth's equatorial plane.

(iii) If the earth rotated clockwise viewed from above the north pole rather than counterclockwise (the true sense of rotation), then at most open ocean ports the time interval from one high tide to the very next high tide would be most nearly

a. 12 hours,
b. 12 hours 25 minutes,
c. 11 hours 35 minutes,
d. 24 hours,
e. 24 hours 25 minutes,
f. 23 hours 35 minutes.

(iv) Suppose that that the sun did not generate tides, and that the moon and its elliptical orbit about the earth were in the earth's equatorial plane, and that the earth rotated on its axis once per month, so that the moon always appeared at the same place in the sky. Then the dominant interval between adjacent high tides would be about

a. 1/2 day, b. one day,
c. two weeks, d. one month,
e. one year.

WAVES. (i), (ii) easy, (iii), (iv) more difficult

(i) Match the kind of wave,

a. capillary waves, b. long swell, c. tsunami in open ocean,
d. sound in water, e. seismic waves in solid earth,

to the following wave speed list

few tens of m/sec _____,
1500 m/sec _____,
few kilometers/s _____,
200 m/sec _____,
few cm/sec to few tens of cm/sec _____.

(ii) The fact that deep water surface gravity waves generated by large storms are dispersive (long waves go faster than short ones) means that at a port distant from a storm, the period of waves arriving from the storm

a. increases, b. decreases, c. does not change

with the passage of time after the storm increases.

(iii) The speed of propagation of ocean surface gravity waves would decrease if gravity

a. increased, b. decreased,

It would also decrease if the density of the water were

a. increased, b. decreased

to a value only somewhat larger than the density of air (hint: don't rely on the wave speed formulas from class, they assumed there was no air. Rather remember that an ocean surface gravity wave is really an internal wave between

the two fluids air and water, ask yourself how the speed of an internal wave would change if the density difference between layers were decreased.)

(iv) The phenomenon of refraction is important both in gravity waves that enter shallow water on the way to the beach and in sound waves that travel vertically in the ocean. In the ocean, sound waves originating at the depth of the sound speed minimum (the SOFAR channel) are generally refracted

a. back towards the center of the SOFAR channel,
b. up or down away from the center of the SOFAR channel.

Consider gravity waves that enter shallow water on the way to the beach. They are refracted as they pass over variable bottom relief. Which feature of bottom relief is analogous to the SOFAR channel in the tendency of refraction to direct gravity waves relative to the center of the relief feature in the same sense that refraction directs sound waves relative to the center of the SOFAR channel?

a. a submarine canyon
b. a submarine ridge (the opposite of a canyon).