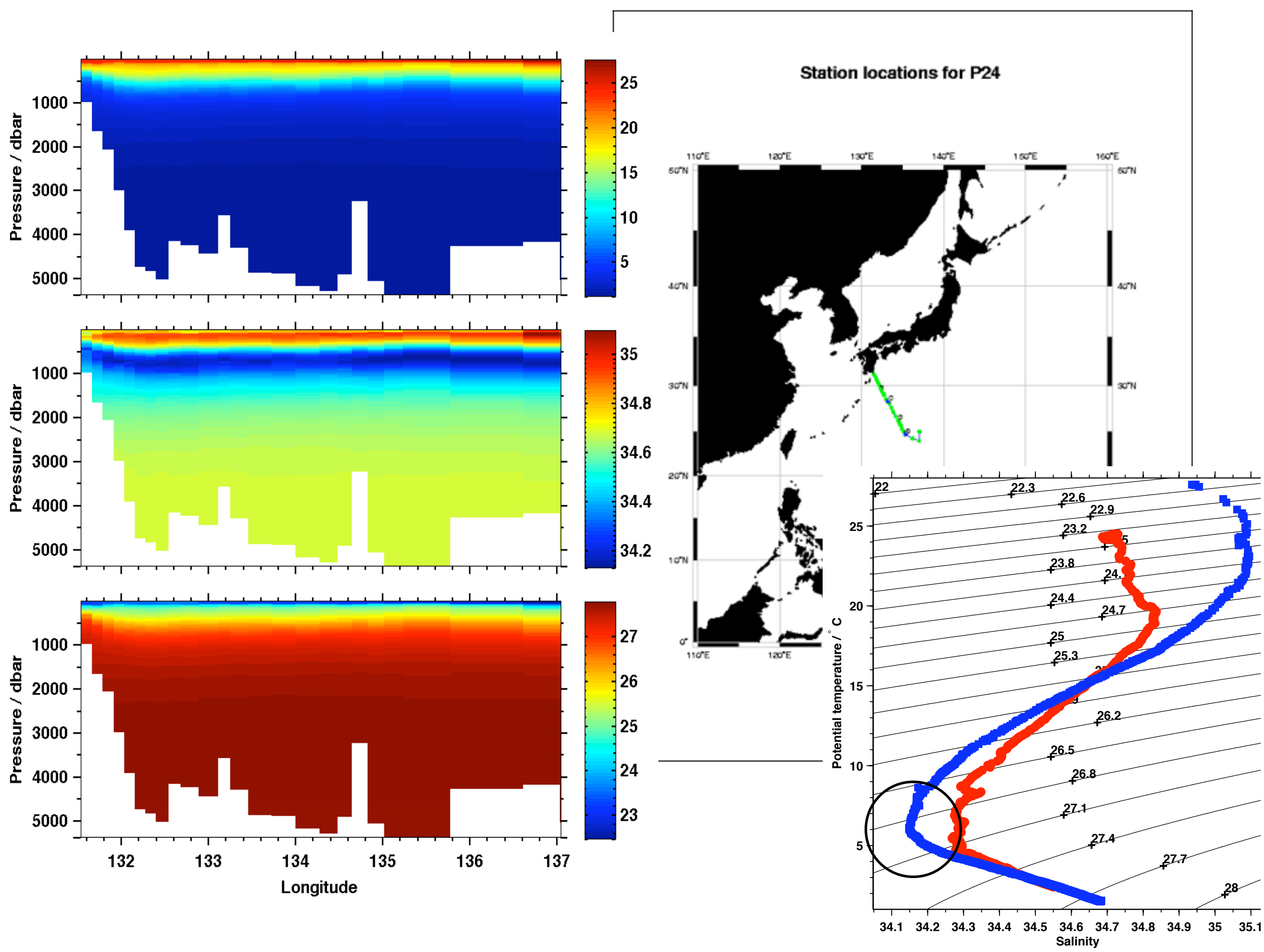
SIO 210 MIDTERM, 26 October 2009.

Please mark your answers on the attached answer sheet, and turn in ONLY THE ANSWER SHEET. Don't forget to put your name on the answer sheet!!

Here are some constants, some of which you might need for the problems below:

c_p=4000 J /(kg ˚C)
α=3* 10^{-4} ˚C^{-1},
$\rho_{seawater}$ = 1025 kg/m^3 (unless otherwise specified)
$\rho_{freshwater}$ = 1000 kg/m^3
ρ_{air} = 1 kg/m^3

Questions 1 through 6 refer to the following data.



1. The plots on the left are measurements of several variables versus longitude and depth. Guess which is which. What variable is plotted in the middle panel?

a. Temperature

b. Potential Temperature

c. Salinity

d. Oxygen

The plots are, from top to bottom, of potential temperature, salinity, and potential density

2. If you could measure pressure along 500 m depth through this section, what pattern would you expect?

a. Steady decrease with longitude

b. Minimum near 131.5

c. Minimum near 137

d. Pressure doesn't vary with longitude, only with depth

Assuming a level of no motion at depth, the areas of relatively light near-surface water correspond to a higher sea surface, while the area of denser near-surface water (near the coast, at the west/left side of this section) correspond to a lower sea surface. So the sea surface, and hence the pressure, is lowest at the west end of this plot, near 131.5.

3. Looking at the upper left corner of the density plot (after identifying it), note the slope of the contours. Though you can't tell from one section, let's say this NW-to-SE section is in the direction of maximum density gradient. Using what you know from the thermal wind equations, what direction do you expect the current to be flowing here?

a. North

b. East

c. North-east

d. South-west

There are a couple ways to think about this. One is to use the thermal wind equation. Near the surface, the density is decreasing with increasing longitude ($d\rho/dx<0$), which tells us that northward velocity gradient is positive, $dv/dz>0$. Assuming a level of no motion at depth the northward component of velocity in the upper ocean is positive. Another way to think about it is to use the pressure you derived for the previous problem. The sea surface slopes upward with increasing x, so the pressure gradient "wants" to push water left/west, but it turns right and goes north. Using BOTH of the thermal wind equations (for u and v), we note that the direction of flow is perpendicular to the direction of maximum density or pressure gradient. So if I tell you that this section is in the direction of maximum density gradient, the flow must be going northeast.

4. At which depth will the current speed be the largest?

a. 0 m

b. 2000 m

c. 5000 m

d. The current will be approximately constant with depth

The thermal wind equation tells us that dv/dz>0. If we assume a level of no motion at depth, then the maximum current is at the surface: z=0 m.

5.   The T-S profiles in the lower right are from either end of this section. Guess where the blue profile is from

a. 131 E
b. 137 E
c. 145 E

The blue profile has significantly saltier and warmer surface water than the red profile. Looking at the section plots, the saltiest surface water occurs at the eastern end of this section, near 137 N.

6. In the T-S plot what type of water do you think is indicated with the black circle?

a. Red Sea Water
b. Circumpolar Deep Water
c. North Atlantic Deep Water
d. North Pacific Intermediate Water

North Pacific Intermediate Water is a low-salinity water mass created at high latitudes where precipitation is larger than evaporation. The two deep water choices are disqualified both because they are relatively salty and because deep water is generally found below 3000 meters or so, while you can see from the sections that this salinity minimum is near 1000 m depth. Red Sea water is very salty.

7. Consider a 10 km long, 5 km wide, 10 m deep lake over which a 0.1 Pa wind stress is blowing parallel to the length of the lake. If the sea surface is unchanged at the lake midpoint, how high would you expect the sea level might be displaced at the downwind end (5 km away from the center-point?). You may want to use $\eta_x = (3\tau^w) / (2\rho gh)$

a. $1.5 * 10^{-6}$ m
b. 1.5 cm
c. 7.5 mm
d. 7.5 cm
e. -7.5 cm

This is a simple case of plugging in to the equation provided. We know all the terms on the right hand side ($\tau^w = 0.1$, $\rho=1000$, $g=10$, $h=10$). The left hand side can be written as $\nabla\eta / \nabla x$, where we are given $\nabla x=5000$ m and we want to solve for $\nabla\eta$. Plugging everything in gives 7.5 mm.

8. Let's say this lake experiences a heat flux of 40 W/m^2 for about 1.2 days (10^5 s). Assuming the heat is evenly distributed, what's the net change in temperature? (you may need some constants from the top of the exam)

a. 0.1 ˚C
b. 0.5 ˚C
c. 1.0 ˚C
d. 2.0 ˚C

You know the relationship between heat flux, heat content, and temperature are governed by the following equations:

$$q = \rho\, c_p\, T$$
$$(\Delta q / \Delta t) = J / h$$

Combining gives you

$$\Delta T = (1/\rho\, c_p) * J * \Delta t / h$$

You know $J=40$, $\Delta t=10^5$, $h=10$, $\rho=1000$, $c_p=4000$. So plugging in gives $\Delta T = 0.1$

9. A high pressure cell in the atmosphere is detected at 30 degrees south (take $f= -0.0001\ s^{-1}$), where the highest pressure is 1010 millibars=101000 Pa. 500 km away from the center the pressure is essentially constant at 1000 millibars. Estimate the wind speed and direction 250 km to the east of the high.

a. 5 ms/ to the N
b. 20 m/s to the S
c. 20 mph to the N
d. 20 m/s to the N
e. 50 m/s to the S

First think about the direction. The pressure gradient is from west to east, so the water "wants" to go east, but because it's in the Southern Hemisphere it turns left=north. To get the magnitude, use the geostrophic equation $v = (1/\rho f) * \Delta p / \Delta x$. You know that the pressure drops 1000 Pa over 500 km, so plugging everything in gives v=20 m/s.

10. Most echosounders are set to a standard sound speed, often 1500m/s. Assume you asked the ship's staff and were told that your one works with 1500m/s and that the depth displayed already is corrected for the depth of the transducer below the surface. You reach your site and get a depth reading of 5000m. You know that the ocean there consists of just 2 equally thick layers with uniform sound speeds, 1450m/s and 1550m/s. What is the true depth of the water ?

a. 4975 m
b. 4994 m
c. 5005 m
d. 5045 m

Correct answer: (b) 4994m solution:

$D_{corr}=hmc/C_{echosounder} * D_{echosounder}$

$hmc= [(1/1450 + 1/1550)/2]^{-1}$ m/s = 1498.3m/s

11. What are the correct descriptions of "irradiance" and "radiance"?

a.irradiance has units of W/m^2, radiance distinguishes the directions the light is coming from
b.irradiance has units of $Wm^{-2}\ sr^{-1}$, radiance integrates over all directions
c.irradiance distinguishes the direction of the light, radiance is energy received by a sphere
d.irradiance is the total energy received by a body in W, radiance is energy per area W/m^2

correct answer: (a)

12. Assume the only light source is the sun vertically above a totally smooth sea surface.The beam absorption coefficient is $a=0.01m^{-1}$, and beam scattering coefficient is $b=0.02m^{-1}$. What is the fraction of the incident intensity left at 1m depth ?

a. 91%
b. 95%
c. 97%
a. 99.9%

correct answer 95% solution:

since light from a single direction, we can use the beam attenuation which is sum of absorption and scattering coefficient. Thus

$I(1m) = I_0 * (1-r) * e^{-(a+b)*1m} = 0.95 I_0$ where reflection coeff $r=0.02$

ANSWER SHEET

Your Name____

Circle one choice for each answer.

1)	a	b	c	d	e
2)	a	b	c	d	e
3)	a	b	c	d	e
4)	a	b	c	d	e
5)	a	b	c	d	e
6)	a	b	c	d	e
7)	a	b	c	d	e
8)	a	b	c	d	e
9)	a	b	c	d	e
10)	a	b	c	d	e
11)	a	b	c	d	e
12)	a	b	c	d	e