SIO 210 Introduction to Physical Oceanography
Mid-term examination
Wednesday, November 2, 2005
2:00 – 2:50 PM

This is a closed book exam. Calculators are allowed. (101 total points.)

MULTIPLE CHOICE (3 points each)

1. Which ocean basin is not characterized by a poleward transport of heat? (circle correct answer)

A) South Indian
B) South Pacific
C) North Pacific
D) South Atlantic

2. Which region of the ocean is most associated with high heat loss to the atmosphere? (circle correct answer)

A) Equatorial Bands
B) Western Boundary Currents
C) Marginal Seas
D) Continental Shelves

3. The characteristic magnitude of annual evaporation over the subtropical gyres is (circle correct answer)

A) 1 cm
B) 10 cm
C) 1 m
D) 10 m

4. The fraction of the ocean ventilated by the wind forced circulation is approximately (circle correct answer)

A) 1/10
B) 1/4
C) 3/4
D) 9/10

5. The moon causes semidiurnal tides (period about 12 hr) and diurnal tides (period about 24 hr) in the ocean because the earth rotates on its axis once every 24 hours. If the earth rotated on its axis once every 48 hours, the periods of the lunar tides would be about (circle correct answer)

a. 6 and 12 h
b. 12 and 24 h
c. 24 and 48 h.

6. The moon rotates on its axis once a month (so that it always keeps the same face turned towards the earth). If there were an ocean on the moon the period of the tide induced by the gravity of the earth would be about (circle correct answer)

a. 6 and 12 h
b. 12 and 24 h
c. 24 and 48 h.
d. 1/2 month
e. one month

(hint: in your answer remember that the distance from moon to earth varies from perigee (closest approach) to apogee (greatest distance) back to perigee about once a month.)

7. In hydrostatic balance (circle correct answer)
a. Vertical acceleration is non-zero.
b. Coriolis force balances the pressure gradient force
c. Gravity balances the pressure gradient force.
d. Pressure depends on water velocity.

SHORT ANSWER (10 points each)

8. A water parcel is adiabatically lowered from the surface to a depth of 4000 meters. What is the rough magnitude of change for each of the following properties? (be sure to indicate if change is positive or negative)

A) Temperature _____
B) Potential Temperature _____
C) Salinity _____
D) Pressure _____

9. Sketch and briefly explain the Hadley circulation in the atmosphere. What

forces the circulation? How is this mode of circulation different in southern and northern hemispheres? Why is it not the same in each hemisphere?

10. (a) The following kinds of wave motion were mentioned in class

A. light
B. sound in air
C. sound in water
D. seismic waves
E. deep water ocean surface gravity waves
F. shallow water ocean surface gravity waves
G. capillary ocean surface waves

Order these waves by propagation speed, putting the fastest first, the next fastest second ... etc., the slowest last. Express your answer by writing the letters that label the different waves in the requested order.

_____

(b) With respect to the list of the previous question (#10), the kind(s) of ocean waves that are energized both in tsunami and in ocean tides are (answer by writing appropriate letter label(s) from list of different waves in previous question). _____

(c) With respect to the list of the previous questions, the kind(s) of ocean waves that are energized by winds over the ocean are (answer by writing appropriate letter label(s) from list of different waves in previous question)._____

11. The three momentum equations can be expressed in words as:

acceleration + advection + Coriolis force = pressure gradient force + gravity + friction
A B C D E F

(a) Which term does not appear in the horizontal momentum equations?

(b) Which terms balance in the Ekman layer driven by the winds at the sea surface?

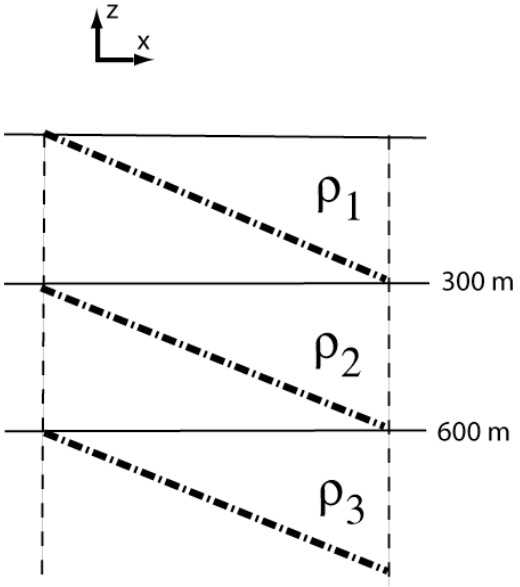
(c) Which terms balance in surface gravity waves?

(d) Which term contains the centrifugal force?

12. The attached plot shows isopycnals in a current in the NORTHERN hemisphere. Assume that we know that the flow is geostrophic and strongest at the sea surface.

(a) Sketch the sea surface height, and indicate roughly how large the variation in surface height is.

(b) Indicate by arrows, arrow heads or arrow tails, the direction and magnitude of geostrophic flow at the sea surface and at a greater depth.



(c) If the Coriolis force were zero, but the sea surface height distribution were as you drew in (b), which direction would the surface water flow?

Long Questions (15 points each)

13. Deep water waves obey the dispersion relation $c = \sqrt{\frac{gL}{2\pi}}$ giving wave speed c (m/s) in terms of wavelength L (m) and the vertical acceleration g~10 m/s^2 of gravity at the earth's surface. Because, by definition c=L/T where T is the wave period (sec), one may also write the wavespeed in terms of wave period; c=gT/(2π).

Suppose that you are standing on the Ocean Beach pier (exposed to the southern ocean) on a winter's day and the period of the incoming swell from a storm in the southern ocean ('southern swell' in the language of the TV weathermen) is about 17 sec.

a. How fast does the 17 sec period swell move? (give formula and numerical results, with units; you may use $\pi = 3.14$, minor arithmetical errors will be tolerated)

b. If the storm is an earth's radius (~6400 km) away, how many days did the waves travel to reach Ocean Beach? (remember 1 day = 86400 s; again give formula as well as numerical answer)

c. How long after the time when you see the 17 sec waves will you see 12 sec waves. Very briefly show the steps by which you obtain your answer.

14. Water flows into a marginal sea at a rate of 10^9 kg/s. The mean temperature of the inflow water is 20 degrees. The marginal sea is a square box with sides of 100 km and depth of 5 km (see accompanying figure) The average heat loss over the sea is 90 W/m^2. Assuming steady state, calculate the temperature of outflowing water.