

ATSC 201  
Prof. Stull  
Fall 2011

**Final Exam**  
(open books, notes, calculator)  
(85 points total  $\approx$  1 point/minute)

Name: \_\_\_\_\_

Student Number: \_\_\_\_\_

1. The attached surface weather map (Figure 1) is valid at 12 UTC on 9 Nov 2011. It already has the fronts, high and low centers, and isobars drawn. The isobar labels are written in a large font size.
  - a) (1 point) Along each front, indicate if it is a cold, warm, stationary, or occluded front.
  - b) (20 points) On that map, draw (in coloured pencil) the following isotherms: 30, 40, 50, 60, 70 degrees Fahrenheit. (Hint, the station plot model already uses degrees F).
  - c) (1 point) Indicate on the map one location where the airmass is likely mT.
  - d) Look at the isobars that encircle the low center and are close to the center. For the second and third isobars from the center, notice that the winds are not parallel to the isobars, but cross the isobars at an angle.
    - (i) (2 points) By eye, estimate the acute angle that these winds cross the isobars, and write your answer here: \_\_\_\_\_ degrees
    - (ii) (3 points) What is the name for this type of wind, and what causes these winds to not blow parallel to the isobars?

Wind name: \_\_\_\_\_ . Reason:
    - (iii) (2 points) In general, how do these winds affect the low-pressure center?
  - e) (1 point) Determine one location on this map where you think thunderstorms would be most likely to be triggered. Indicate this location on the map by drawing the weather-map symbol for a thunderstorm.

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2. The attached upper-air chart (Figure 2) shows heights of the 50 kPa isobaric surface, corresponding to the same date and time as the previous surface chart. If you put a decimal point two places from the right, then the height-contour labels have units of km. (e.g., 540 means 5.40 km).
  - a) (2 points) This map shows generally lower heights (e.g., 5.28 km) to the north, and higher heights (e.g., 5.82 km) to the south. Why is this expected dynamically or thermodynamically, based on characteristics of the global circulation?

b) (2 points) On this map, draw dashed lines to indicate the axis of each major trough, and draw zig-zag lines to indicate the axis of each major ridge.

c) (1 point) Notice that the winds almost everywhere on this chart are parallel to the height contours. What is the name of a theoretical wind that has such characteristics? \_\_\_\_\_

d) (i) (1 point) Starting near the middle of the left edge of the map, draw a series of arrows (head to tail) on this map showing a jet-stream streamline as it progresses all the way across this chart.

(ii) (2 points) What drives this jet stream?

e) The winds on this map are in units of knots.

(i) (3 points) On the map, draw isotachs for wind speeds of 50 and 70 knots.

(ii) (1 point) On the map, write the words "jet streak" in the center or centers of these region(s) of fast wind speed.

f) (i) (1 point) Are there any Rossby waves evident in this map? (Circle one: Yes No )

(ii) (1 point) If so, what is the dominant wavelength (km)? \_\_\_\_\_

(Hint: The approximate distance from Vancouver to the Atlantic Ocean is roughly 5000 km).

g) (3 points) Why are the north-south meanders of the jet stream affected by the variation in the Coriolis parameter?

h) (8 points) Calculate the intrinsic phase speed (m/s) of these Rossby waves?

i) (3 points) Relative to the locations of the troughs and ridges in the jet stream, there are certain regions where flow divergence is expected.

(i) Write a "D" on this chart at the location(s) on the jet stream (from part d) of such divergence aloft.

(ii) What is the significance of such divergence with regards to extratropical cyclones?

j) (2 points) For the 50 kPa isobaric map, the flow is predominantly (Circle one: zonal ; meridional). Why?

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3. Figure 3 is another surface weather map, but for the next day (i.e., for 12 UTC on 10 Nov 2011).

a) (1 points) What is the local time in Vancouver corresponding to the time of this map? \_\_\_\_\_

b) (4 points) (i) During the time period between 9 November and 10 November, the extratropical cyclone has (Circle one: strengthened ; not much change ; weakened ).

(ii) What evidence do you have for this, from the weather maps?

c) (2 points) Also on this map is a tropical low-pressure center named "Sean".

(i) What is the type of this tropical system? Circle one:

( tropical disturbance , tropical depression , tropical storm , hurricane ).

(ii) What max surface wind speed (m/s) would be anticipated with this system? \_\_\_\_\_

d) (2 points) On this map, draw an arrow (with the tail on the tropical low center) showing the direction this tropical system will likely move during a day.

e) (i) (1 point) At the tropopause directly above the surface center of this tropical system, you anticipate a (Circle one: high-pressure center ; low-pressure center )

(ii) (2 points) Why?

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4. a) (2 points) What do anabatic winds and sea breezes have in common?

b) An arctic outbreak is causing cA air to flow through a short gap in a mountain range. This cold air has temperature  $-10^{\circ}\text{C}$ , but above it is a strong temperature inversion capped by air that is  $15^{\circ}\text{C}$  warmer (assume  $\Delta T \approx \Delta \theta_v = 15^{\circ}\text{C}$ ).

(i) (4 points) If the gap depth is 500 m, then what is the value of the fastest wind speed (m/s) that can flow through the gap?

(ii) (2 points) What prevents the winds from having faster speed through this gap?

c) (5 points) Suppose statically stable air has a Brunt-Väisälä frequency of  $0.02\text{ s}^{-1}$ . If this air has an average wind speed of 20 m/s as it blows over a mountain range, what width (km) mountain range will cause the most violent (i.e., resonant) mountain wave?