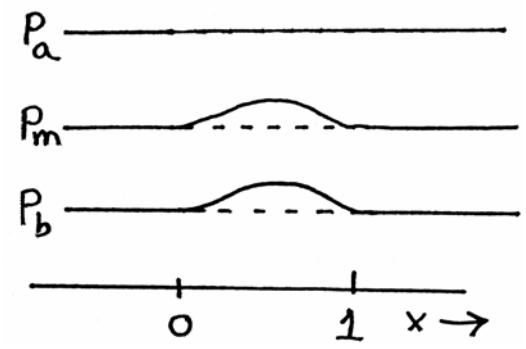
ATM 111 Final 2007 Name:_____ 10
50 pts

1. Surface P tendency equation:

(a) (2 pts) Consult the diagram at right. There are two layers of air. The layers are defined by the pressure surfaces: P_a , P_m , and P_b . The dashed lines are constant heights. For the range 0<x<1, circle the correct answer:



In the lower layer there is
(CAA, WAA, negligible T advection.).

In the upper layer there is
(CAA, WAA, negligible T advection.).

(b) (2 pts) The approximate formula (4.11c) for surface pressure (P) is:

$$-\left(\frac{\partial p}{\partial t}\right)_S = a\left\{-V_{g5}\bullet\nabla_p\left(\zeta_{g5}+f\right)\right\} + b\left\{-V_{g0}\bullet\nabla_p h\right\} \qquad (4.11c)$$

where a>0, b>0 and other variables have their usual meanings. Circle the correct answers:

When there is upper level NVA, there are surface pressure (rises, falls).

When there is WAA, there are surface pressure (rises, falls).

2. Vertical component vorticity equation.

$$\frac{\partial\zeta}{\partial t} = \mathrm{A}+\mathrm{B}+\mathrm{C}+\mathrm{D}+\mathrm{E} = \underset{\mathrm{A}}{-V_g\bullet\nabla(\zeta+f)} \underset{\mathrm{B}}{-\omega\frac{\partial\zeta}{\partial P}} \underset{\mathrm{C}}{+(\zeta+f)\left\{\frac{\partial\omega}{\partial p}\right\}} \underset{\mathrm{D}}{-\left(\frac{\partial\omega}{\partial x}\frac{\partial v}{\partial p}-\frac{\partial\omega}{\partial y}\frac{\partial u}{\partial p}\right)} \underset{\mathrm{E}}{+\left\{\frac{\partial F_y}{\partial x}-\frac{\partial F_x}{\partial y}\right\}}$$

a. (2 pts) Fill in each blank with the letter label that matches the name of the term.

Divergence term _____ Vertical advection term _____

b. (4 pts) Describe how the horizontal advection (HA) and divergence (DT) terms typically affect the propagation of a trough at 900 and at 300 hPa.

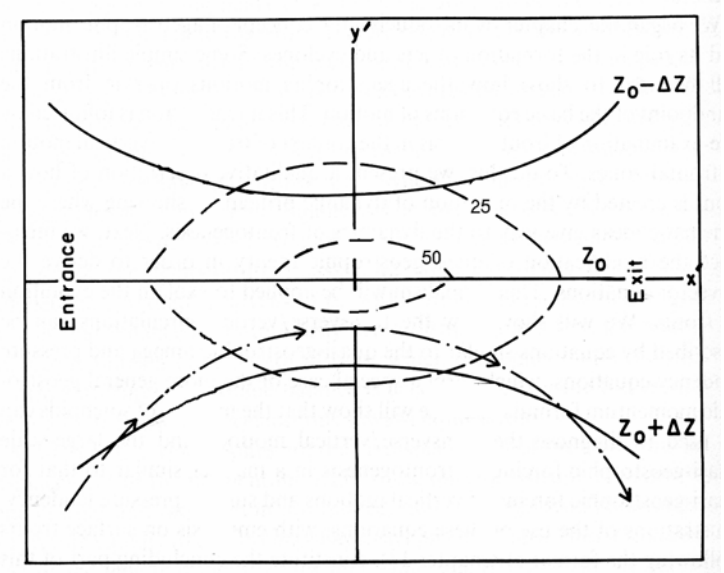
3. Jet streak discovery problem. Here you apply your knowledge from various parts of the course to deduce why there is rising/sinking motion associated with a jet streak in a characteristic pattern. The diagram has these properties:
Dashed lines: isotachs in m/s
Solid curving lines: geopotential height contour.
Dot-dashed line: a typical trajectory on the S side of the jet streak. (A trajectory on the N side would be a mirror image.)

Circle correct answers:
a. (1 pt) Air at jet stream level moves (slower, the same speed, faster) than the jet streak

b. (1 pt) Wind speed (decreases, stays about the same, increases) as pressure increases.

Mark on diagram:
c. (2 pts) Place on the diagram a capital '**U**' where rising motion is likely in the air below the jet streak level.

d. (2 pts) At the jet streak level, estimate where relative vorticity has a positive maximum and a negative extremum (largest magnitude, but negative sign). Place a big '**C**' symbol centered on the positive maximum and a big '**A**' at the negative extremum.



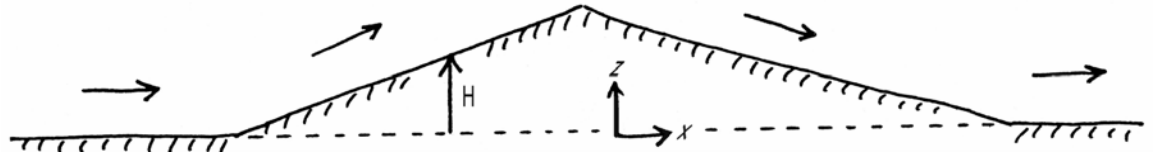
e. (4 pts) Deduce where there is PVA and place a '**P**' where that is occurring at jet streak level and an '**N**' for NVA.

Short answer:
f. (4 pts) Deduce how there can be rising motion where you have indicated it, from the information above and the QG 'omega' equation (below). (You don't need any math here, description in words is sufficient; eqn provided to assist your memory.)

$$A_1 \nabla^2 \omega + A_2 \frac{\partial^2 \omega}{\partial P^2} = A_3 \frac{\partial}{\partial P}\left\{V_g \bullet \nabla\left(\zeta_g + f\right)\right\} - \nabla^2\left[V_g \bullet \nabla \frac{\partial Z}{\partial P}\right]$$

ans: Where there is PVA that is increasing with height (NVA decreasing with incr elevation not relevant here) or PVA that decreases as P increases, then omega equation says upward motion is being forced.
Total the problem has 14 pts.

4. Slope flow: Consider air flowing up then down a north-south oriented mountain range as in the diagram.

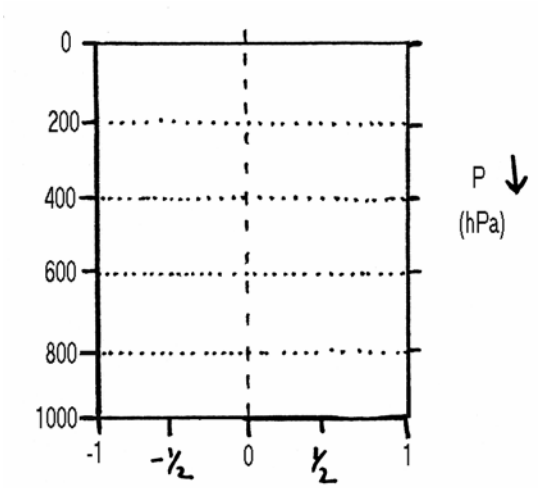


a. (4 pts) For each item, indicate if the quantity is > 0, = 0, or < 0 on the **lee side** of the mountain.

ω _____ 0 $\partial\omega/\partial P$ _____ 0 Convergence _____ 0

total derivative of relative vorticity in QG vorticity equation _____ 0

b. (4 pts) Assume that $\omega = -\rho g w$. On the blank diagram provided, draw a vertical profile of pressure velocity (ω)for slope flow at a point where the ground has 800 mb pressure on the *windward* side.
Then plot the *magnitude* for the "bowstring" model *and*.
For both profiles of ω assume that the vertical motion goes to zero at the 200 mb level. Also assume the maximum magnitude is 1.0 in both cases.



5. (7 pts) True (T) or False (F), circle the correct judgement for each statement below.

T F In the quasi-geostrophic (QG) system the velocities doing the advecting are geostrophic.

T F Developing surface cyclones tend to move parallel to the 1000/500 mb thickness contours

T F Veering is a term for turning of the wind where there is cold advection.

T F In the QG omega equation the most prominent term tends to be: thickness advection for short waves and vorticity advection for long waves.

T F An occlusion is formed when a cold front overtakes a warm front.

T F Potential temperature decreases as height and latitude increase.

T F 'Dines' compensation' means the vertical integral of divergence is small.

6. (6 pts) Answer questions regarding the equations listed below:

		Valid at approximately the level →	surface	500 mb
QGVE:	$\frac{\partial \xi_a}{\partial t} = -\vec{V} \bullet \nabla_p \xi_a + f \frac{\partial \omega}{\partial p}$		____	____
EBVE:	$\frac{\partial \xi_*}{\partial t} = -\vec{V}_* \bullet \nabla_p \xi_* + \frac{f_o \omega_s}{p_s} \overline{A^2(p)}$		____	____
BEBVE:	$\frac{\partial \xi_m}{\partial t} = -\vec{V}_m \bullet \nabla_p \xi_m \ -\overline{B^2(p)}\, \vec{V}_T \bullet \nabla_p \xi_T + \frac{f_o \omega_s}{p_s}$		____	____

a. By means of one or more check marks in the space provided to the right of each equation, indicate at what level(s) the formula would be appropriate to use.

b. Circle those terms responsible for development.

7. Stages of cyclone development.

a. (5 pts) Below is a diagram of the cloud pattern at the 4th stage. Analyze the following information on that diagram.

i. surface fronts using standard notation

ii. jet streak location using a letter J.

iii. location of the warm conveyor belt with an arrow and the letters: WCB.