METR 2413 QUIZ 5 **NAME______________________________**

Answer all questions briefly. DUE in 15 minutes!

1. Write down a line of html code to provide a link from the text “This is my picture” to the file `picture.gif` in the same directory as the html file.

** This is my picture ** **(2 points)**

2. Using the following typical magnitudes for synoptic scale flow:
   vertical distance ~ 10 km, horizontal distance ~1000 km, horizontal wind ~ 10 m/s,
   horizontal pressure variation ~ 10 hPa, gravitational acceleration g ~ 10 m/s^2,
   density ~ 1 kg/m^3, Coriolis parameter ~ 10^{-4} s^{-1}

(a) What is the magnitude of the vertical pressure gradient force per unit mass, and what balances this component of the pressure gradient force? (Show your working.)

Vertical pressure gradient force per unit mass is 1/? ?p/?z = -g ~ 10 m/s^2

Vertical pressure gradient force is balance by weight force, or downward gravitational acceleration **(4 points)**

(b) What is the magnitude of the horizontal pressure gradient force per unit mass, and what balances this component of the pressure gradient force? (Show your working.)

Horizontal pressure gradient force is 1/? ?p/? x ~ 1/1 m^3/kg × 10 hPa / 1000 km
~ 1 m^3/kg × 1000 Pa / 10^6 m ~ 10^{-3} m/s^2

This is balanced by the Coriolis force

(4 points)

(c) What is the magnitude of the Coriolis force per unit mass in the horizontal? (Show your working.)

Coriolis force per unit mass, fv ~ 10^{-4} s^{-1}× 10 m/s ~ 10^{-3} m/s^2

(3 points)

Please turn over, more questions on the other side.

3. The hypsometric equation for the thickness between two pressure levels can be written

$$z_2 - z_1 = -\frac{R_d \overline{T}_v}{g} \ln(\frac{p_2}{p_1}) = \frac{R_d \overline{T}_v}{g} \ln(\frac{p_1}{p_2})$$

The 540 dam thickness contour on a 1000-500 hPa thickness chart is used to indicate the likelihood of snow falling. What layer mean virtual temperature does a thickness of 540 dam correspond to, if ln(2)= 0.69, R = 287 and g = 9.8 m/s^2 ?

$$\overline{T}_v = \frac{g}{R_d} \frac{(z_2 - z_1)}{\ln(p_1 / p_2)} = \frac{9.8}{287} \frac{540 \times 10}{0.69} \approx 267K$$

(3 points)

4. Use the thermal wind relation $\frac{\Delta u_g}{\Delta z} = -\frac{g}{\mathrm{f_c} \overline{T}_v} \frac{\Delta T_v}{\Delta y}$

to explain briefly why the mean westerly winds in middle latitudes increase with height in the Northern Hemisphere.

On average, in the NH, temperatures decrease towards the north, so ?T/?y < 0.
With g and T_v positive constants and f_c > 0 in the NH, then the right hand side > 0. Hence ? u_g/?z > 0 and the mean geostrophic westerly wind increases with height in the NH.

Please turn over, more questions on the other side.