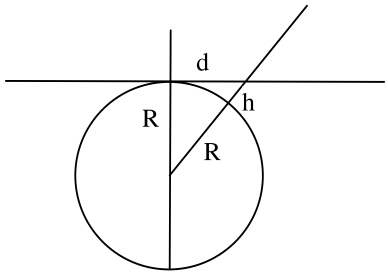
Atmospheric Dynamics

Solutions to Tutorial Questions on Chapters 4

1) The configuration is as shown
Applying Pythagoras's theorem gives

$$R^2 + d^2 = (R+h)^2$$
$$\approx R^2 + 2Rh$$



So that

$$h \approx \frac{d^2}{2R}$$

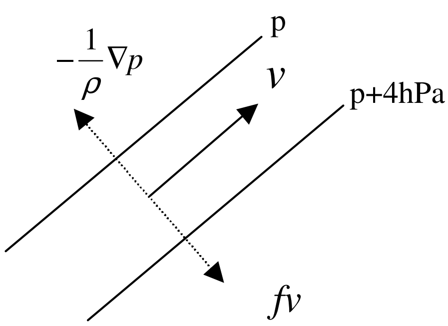
Leading to

D/km	H/km
200	3.4
500	19.6
1000	78.4

2) The only subtle point to note here is that Ω has to be measured with respect to the fixed stars. Now, although there are 365.25 solar days in a year, the earth actually rotates once more than this when seen from the fixed stars. This may most easily be seen by considering what would happen if it were rotating just once in a year – in which case the sun would always be overhead in the same longitude. Thus in one solar day the earth rotates $2\pi\left(\frac{366.25}{365.25}\right)$ radians, leading to the quoted value for Ω.

3)

$$\frac{1}{\rho}\nabla p = \frac{m^{-3}}{1.2kg}\frac{400Pa}{100\times km}$$
$$= 3.33\times10^{-3}ms^{-2}$$



Specific Coriolis force

$= fv = 10^{-4} s^{-1} 30 ms^{-1}$
$= 3 \times 10^{-3} ms^{-2}$

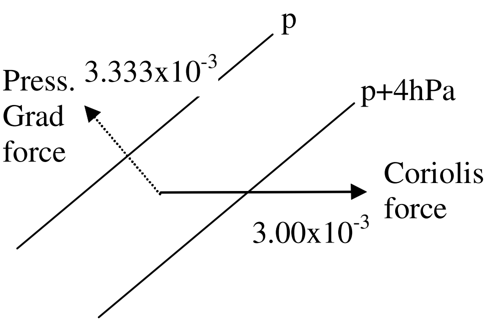
The acceleration will be produced by the difference between these two forces. Since they are in the same straight line but in opposite directions the vector difference is easy to compute and is readily seen to be

$$\boxed{0.333 \times 10^{-3} ms^{-2} \text{ towards the NW.}}$$

or

$$\boxed{28.8 ms^{1} \text{ per day towards the NW.}}$$

2) This new case differs from the previous question only in that the wind comes from the south. This means that the Coriolis force is directed to the east. Thus the configuration of forces and isobars looks like the sketch to the right.

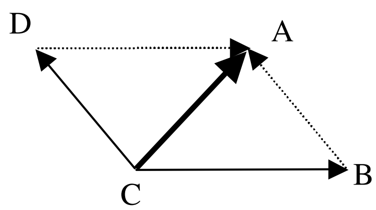


The sketch below that shows the configuration of the forces and the acceleration. CB represents the specific Coriolis force, CD represents the specific pressure gradient force, and CA represents the resultant, which produces the acceleration.

BA has magnitude $3.333 \times 10^{-3} ms^{-2}$

CB has magnitude $3.000 \times 10^{-3} ms^{-2}$

Angle CBA is 45 degrees



Using cosine rule allows AC to be found:-

$$AC^2 = AB^2 + CB^2 - 2AB.CB.\cos 45$$

This gives the magnitude of the acceleration.

$$\boxed{\text{Magnitude of acceleration} = 2.44 \times 10^{-3} ms^{-2} = 211 ms^{-1} day^{-1}}$$

To get the direction we need say the angle ACB. Now that the magnitude of AC is known, we can use the sine rule thus

$$\frac{\sin(ACB)}{AB} = \frac{\sin(CBA)}{AC}$$

This gives

$$\boxed{\text{angle } ACB = 28.7^o}$$

This is a huge acceleration, but we would not normally find the two forces as far out of balance as in this question.