Exercise 1: Balloons in the Atmosphere (0)

(a) Typical hot air balloons on sightseeing tours have a volume of approximately $3000\,\mathrm{m}^3$. A typical gross weight, i.e. balloon, basket, fuel and passengers, but without the air in the balloon is approximately $600\,\mathrm{kg}$. If the temperature at ground is $20\ °C$, the temperature gradient $0\,\mathrm{K\,km}^{-1}$ and the balloon is in hydrostatic equilibrium at a cruising altitude at $900\,\mathrm{hPa}$, which temperature has the air inside the balloon?

(b) Suppose an identical gross weight of two balloons. Both cruise together under dry conditions at same altitude with a surrounding air temperature of $0\ °C$. One balloon is filled with helium the other is filled with hot air. The volume of the He-balloon is $1000\,\mathrm{m}^3$. If the air temperature inside the hot air balloon is $90\ °C$, which volume has that balloon?

Exercise 2: Adiabatic Ascent (0)

A dry air mass rises in the atmosphere adiabatically from $1000\ hPa$ to $700\ hPa$. The temperature of the particle and the moving air is $10\ °C$ in $1000\ hPa$. Calculate the

(a) density and the specific volume at $1000\ hPa$,

(b) specific volume and temperature in $700\ hPa$,

(c) change in the specific internal energy and in the specific enthalpy (for the enthalpy it is: $dh = c_p\ dT$).

Exercise 3: Measures of humidity (0)

(a) At ground the pressure is $p = 1000\ \mathrm{hPa}$, the temperature is $T = 300\ \mathrm{K}$ and the absolute humidity is $a = 10.0\ \mathrm{g/m}^3$. Calculate the vapour pressure, relative humidity, dew point and specific humidity. *Hint*: To determine the saturation vapour pressure and the dew point use the empirical Magnus formula:

$$e_s(T) = 6.11 \cdot exp\left(\frac{17.1 \cdot T}{235 + T}\right)\ \mathrm{hPa}$$, whereby T is the temperature in $°\mathrm{C}$.

(b) Suppose the air pressure to be $1026.8\ \mathrm{hPa}$ and the air contains water vapour at a mixing ratio of $5.50\ \mathrm{g/kg}$. What is the value of the water vapour pressure?

Exercise 4: Mass of condensed water (0)

An air volume of 20.0 liters at a temperature of $20.0\ °\mathrm{C}$ and a relative humidity of $60.0\ \%$ is isothermically compressed to a volume of 4.00 liters. Calculate the mass of the condensed water. *Hint*: To determine the saturation vapour pressure use the Magnus formula (cf. Measures of humidity). The air density at $0\ °C$ und $1000\ \mathrm{hPa}$ is $1.28\ \mathrm{kg/m}^3$.

Exercise 5: Apparent forces (0)

(a) Explain the deviation of an object moving from a pole to the equator and vice versa. Explain the hemispheric difference.

(b) Explain the deviation of an object moving from west to east in the mid-latitudes and vice versa. Explain also the hemispheric difference. Make a sketch and draw the accelerations.

(c) Give the components of the Coriolis acceleration at a wind vector of $(u, v, w) = (15\ \mathrm{m/s}, 5\ \mathrm{m/s}, 0.002\ \mathrm{m/s})$ at the pole, in $45°N$ and at the equator?

(d) An air parcel is moving westward at $20\ \mathrm{ms}^{-1}$ along the equator. Compute the apparent acceleration toward the center of the Earth from the point of view of an observer external to the Earth and in a coordinate system rotating with the Earth.

(e) Consider once more (d). Compute now the apparent Coriolis force in the rotating coordinate system.

(f) A projectile is fired vertically upward with velocity w_0 from a point on Earth. Show that in the absence of friction the projectile will land at a distance

$$\frac{4w_0^3\Omega}{3g^2}\cos\varphi,$$

where φ is the geographical latitude, to the west of the point from which it was fired.

(g) Calculate the displacement for a projectile considered in (f) fired upward on the equator with a velocity of $500\ \mathrm{m/s}^{-2}$.

Good luck and have fun!!!