

Problem 3: Hot-air-balloon

Consider a hot-air balloon with fixed volume $V_B = 1.1 \text{ m}^3$. The mass of the balloon-envelope, whose volume is to be neglected in comparison to V_B , is $m_H = 0.187 \text{ kg}$.

The balloon shall be started, where the external air temperature is $\vartheta_1 = 20 \text{ }^\circ\text{C}$ and the normal external air pressure is $p_0 = 1.013 \cdot 10^5 \text{ Pa}$. Under these conditions the density of air is $\rho_1 = 1.2 \text{ kg/m}^3$.

- a) What temperature ϑ_2 must the warmed air inside the balloon have to make the balloon just float?
- b) First the balloon is held fast to the ground and the internal air is heated to a steady-state temperature of $\vartheta_3 = 110 \text{ }^\circ\text{C}$. The balloon is fastened with a rope.

Calculate the force on the rope.

- c) Consider the balloon being tied up at the bottom (the density of the internal air stays constant). With a steady-state temperature $\vartheta_3 = 110 \text{ }^\circ\text{C}$ of the internal air the balloon rises in an isothermal atmosphere of $20 \text{ }^\circ\text{C}$ and a ground pressure of $p_0 = 1.013 \cdot 10^5 \text{ Pa}$. Which height h can be gained by the balloon under these conditions?
- d) At the height h the balloon (question c)) is pulled out of its equilibrium position by 10 m and then is released again.

Find out by qualitative reasoning what kind of motion it is going to perform!