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Exercises and Complements for the Introduction to Physics I for Students of Biology, Pharmacy and Geoscience

Sheet 8 / October 13, 2017 **Solutions**

Exercise 31.
The height of the water column due to capillary forces can be described by the following equation:

$$h = \frac{2\sigma}{\varrho g r} = 14.3\,mm$$

where σ is the surface tension and ρ is the density of water.

Exercise 32.
According to the Hagen-Poiseuille equation, the pressure difference ΔP depends on the volume flow rate I_V:

$$\Delta P = \frac{8\eta l}{\pi r^4} I_V$$

where η is the viscosity, l the length and r the radius of the capillary. The volume flow rate I_V is determined by the product of the cross-sectional area A of the capillary and the flow rate v: $I_V = A_{Kap} v = \pi r^2 v$. By inserting this in the previous equation and solving it for the viscosity η we obtain:

$$\eta = \frac{\pi r^4 \Delta P}{8 l I_V} = \frac{r^2 \Delta P}{8 l v} = 3.98\,mPa \cdot s$$

Exercise 33.
The gravitational force of the mass m added on the right side need to be compensated by the buoyancy force F_A acting on the cube in the water. From this the following equation results:

$$|F_A| = F_{G,W} = m_W g = \varrho_W V_W g = \varrho_W V_K g$$

where V_W is the volume of the suppressed water which is equal to the volume of the cube V_K. The gravitational force of the mass m added on the right side is $F_G = mg$. The absolute value of it should be equal to the buoyancy force:

$$\varrho_W V_K g = mg$$

From this it follows for m added on the right side:

$$m = \varrho_W V_K = 64\,g$$

Exercise 34.
We use the Bernoulli equation:

$$p_u + \frac{1}{2}\rho v_u^2 = p_o + \frac{1}{2}v_o^2$$

where p_u is the pressure on the surface below the wing, p_o is the pressure on the surface above the wing, ρ is the density of the air, v_u is the velocity of the airflow below and v_0 above the wing. We assume that both flow channels are at the same height. We solve the equation for v_0 and use $p_u - p_o = 900\,\mathrm{Pa}$ (given in the problem)

$$v_o = \sqrt{\frac{2(p_u - p_o)}{\rho} + v_u^2} = 116\,m/s$$

Exercise 35.
According to Stokes law the friction force F_R is:

$$F_R = 6\pi\eta r v$$

The acceleration is $a = 0$ in the case of constant velocity and we have a balance of forces:

$$\varrho_{Stahl} V g = 6\pi\eta r v + \varrho_{Gly} V g$$

We solve the equation for v:

$$v = \frac{Vg(\varrho_{Stahl} - \varrho_{Gly})}{6\pi\eta r}$$

with $V = \frac{4}{3}\pi r^2$ it follows

$$v = \frac{2r^2 g}{9\eta}\left(\varrho_{Stahl} - \varrho_{Gly}\right) = 2.45 \cdot 10^{-3}\,m/s$$