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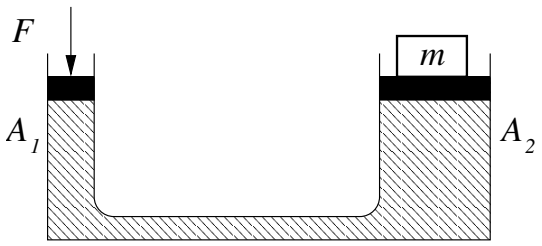
Exercises and Complements for the Introduction to Physics I for Students of Biology, Pharmacy and Geoscience

Sheet 7 / October 13, 2017 Discussion of the Exercises: **07.11.2017/08.11.2017**

Exercise 27.

A mass of $m = 1.5$ t should be slightly lifted with the use of a hydraulic system (cross section of the pistons $A_1 = 20$ cm^2, $A_2 = 0.36$ m^2), see figure. The mass of the big piston is $m_K = 100$ kg. Compared to that, the mass of the small piston is much smaller and therefore can be neglected. The pistons are at the same height. How big should the force F applied to the small piston be in order to lift m?

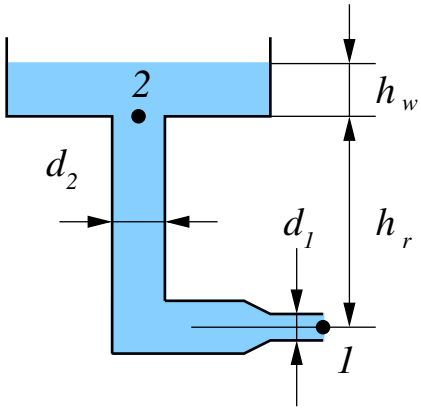


Exercise 28.

The transport of water from the roots to the leaves of a tree is realized through capillaries by the use of surface tension. Assume the density of nutrients containing water to be $\rho = 1.01$ kg/dm^3, the surface tension towards air is $\sigma = 0.073$ N/m and the angle at the edge is $\theta = 23$ degrees. How big is the maximum diameter of the capillary for a 12 m tall tree?

Exercise 29.

The level of the water in a big open water containing container is kept constant at a height of $h_w = 4$ m by continuously adding water. A tube with a diameter of $d_2 = 60$ mm and a height of $h_r = 10$ m gets narrower at the horizontal opening; see figure. There the diameter is reduced to $d_1 = 40$ mm. The air pressure is constant of 990 mbar. Calculate:



(a) the flow rate at the exit v_1 (position 1).
(b) the flow rate v_2 at position 2.
(c) the pressure p_2 at the entrance (position 2).

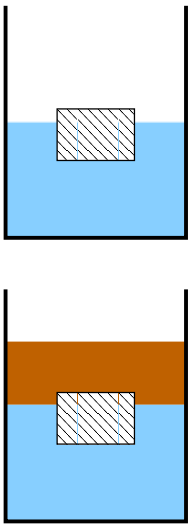
Exercise 30.

A reservoir is emptied via four tubes which are positioned next to each other. Each tube is l long and has a radius of $r_0 = 0.1$ m. The four tubes should be replaced by a single tube with a radius of r_1. The flowing resistance and the length l should be the same for both cases.

(a) Calculate r_1.
(b) The flow of the volume I_v should be equal in both cases. How big is the Reynolds number for the second case (Re_1) compared to the first (Re_0)?
(c) For which case is a turbulent flow more probable if you assume that the critical Reynolds number is the same for both cases? Explain your answer.

Additional Exercises (not relevant for the exam)

A wooden cuboid floats in a glass of water, see figure. 90% of its volume enters the water



(a) Calculate the density of the wood.
(b) We add oil ($\rho = 0.85 \cdot 10^3$ kg/m^3) to the water till the cuboid is completely covered, see figure. Is the volume entering the water bigger, smaller or equal than before? Argue qualitatively.
(c) Calculate the percentage of the volume which enters the water for the case described in (b).

Solutions:

Exercise 26. 87.2 N

Exercise 27. 2.26 μm

Exercise 28. (a) 16.57 m/s (b) 7.36 m/s (c) 1.11 bar

Exercise 29. (a) 0.141 m (b) $Re_0/Re_1 \frac{1}{2\sqrt{2}}$

Additional Exercise (a) 0.9 * ρ_w, (c) 1/3