Universität Leipzig, Fakultät für Physik und Geowissenschaften

Exercises for Experimental Physics 1 – IPSP

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Exercise Sheet 11 (WS 2011/12)

Date of Issue: Jan. 6^{th} 2012

Date of Submission: Jan. 13^{th} 2012

Submission Place: Marked mailbox next to room 302 (Linnestr. 5)
Submission Time: 11:00 a.m. at the submission day noted above

Please note: Write your name and matriculation number on EACH sheet of paper. Only submit the calculations and results for exercise 1-3, exercise 4 will be discussed during the instruction classes.

Exercises:

1. Since 1983, the US Mint has coined pennies that are made out of zinc with a copper cladding. The mass of this type of penny is 2.50 g. Model the penny as a uniform cylinder of height 1.23 mm and radius 9.50 mm. Assume the copper cladding is uniformly thick on all surfaces. If the density of zinc is 7140 kg/m^3 and that of copper is 8930 kg/m^3, what is the thickness of the copper cladding? (7 Points)

2. The volume of a cone of height h and base radius r is $V = \pi r^2 h/3$. A jar in the shape of a cone of height 25 cm has a base with a radius equal to 15 cm. The jar is filled with water. Then its lid (the base of the cone) is screwed on and the jar is turned over so its lid is horizontal. (a) Find the volume and weight of the water in the jar. (b) Assuming the pressure inside the jar at the top of the cone is equal to 1 atm, find the excess force exerted by the water on the base of the jar. Explain how this force can be greater than the weight of the water in the jar. (6 Points)

3. Your team is in charge of launching a large helium weather balloon that is spherical in shape, and whose radius is 2.5 m and total mass is 15 kg (balloon plus helium plus equipment). (a) What is the initial upward acceleration of the balloon when it is released from sea level? (b) If the drag force on the balloon is given by $F_D = \frac{1}{2}\pi r^2 \rho v^2$, where r is the balloon radius, ρ is the density of air, and v the balloon's ascension speed, calculate the terminal speed of the ascending balloon. (7 Points)

4. A large keg of height H and cross-sectional area A_1 is filled with root beer. The top is open to the atmosphere. There is a spigot opening of area A_2, which is much smaller than A_1, at the bottom of the keg. (a) Show that when the height of the root beer is h, the speed of the root beer leaving the spigot is approximately $\sqrt{2gh}$. (b) Show that if $A_2 \ll A_1$, the rate of change of the height h of the root beer is given by $\frac{dh}{dt} = -\frac{A_2}{A_1}\sqrt{2gh}$. (c) Find h as a function of time if $h = H$ at $t = 0$. (d) Find the total time needed to drain the keg if $H = 2.00\,m$, $A_1 = 0.800\,m^2$, and $A_2 = 1.00 \cdot 10^{-4}\,A_1$. Assume laminar nonviscous flow.