Universität Leipzig, Fakultät für Physik und Geowissenschaften

# Exercises for Experimental Physics 2 – IPSP

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## Exercise Sheet 8 (SoSe 2012)

Date of Issue: June $1^{st}$ 2012

**Date of Submission: June $8^{th}$ 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. A point particle of mass $m$ and charge $q$ is constrained to move vertically inside a narrow, frictionless cylinder (Figure 1). At the bottom of the cylinder is a point charge $Q$ having the same sign as $q$. (a) Show that the particle whose mass is $m$ will be in equilibrium at a height $y_0 = (k\,q\,Q/m\,g)^{1/2}$ ($k$ = const.). (b) Show that if the particle is displaced from its equilibrium position by a small amount and released, it will exhibit simple harmonic motion with angular frequency $\omega = (2g/y_0)^{1/2}$. (8 Points)

2. Two neutral molecules on the $x$ axis attract each other. Each molecule has a dipole moment $\vec{p}$, and these dipole moments are on the $+x$ axis and are separated by a distance $d$. Derive an expression for the force of attraction in terms of $p$ (absolute value) and $d$. (5 Points)

3. A gold nucleus is 100 fm (1 fm = $10^{-15}$ m) from a proton, which initially is at rest. When the proton is released, it speeds away because of the repulsion that it experiences due to the charge on the gold nucleus. What is the proton's speed a large distance (assume to be infinity) from the gold nucleus? (Assume the gold nucleus remains stationary.) (7 Points)

4. During the Millikan experiment used to determine the charge on the electron, a charged polystyrene microsphere is released in still air in a known vertical electric field. The charged microsphere will accelerate in the direction of the net force until it reaches terminal speed. The charge on the microsphere is determined by measuring the terminal speed. During one such experiment, the microsphere has radius of $r = 5.50 \cdot 10^7$ m, and the field has a magnitude $E = 6.00 \cdot 10^4$ N/C. The magnitude of the drag force on the sphere is given by $F_D = 6\pi\eta r v$, where $v$ is the speed of the sphere and $\eta$ is the viscosity of air ($\eta = 1.8 \cdot 10^{-5}\,N\,s/m^2$). Polystyrene has density $1.05 \cdot 10^3\,kg/m^3$. (a) If the electric field is pointing down and the polystyrene microsphere is rising with a terminal speed of $1.16 \cdot 10^4\,m/s$, what is the charge on the sphere? (b) How many excess electrons are on the sphere? (c) If the direction of the electric field is reversed but its magnitude remains the same, what is the new terminal speed?

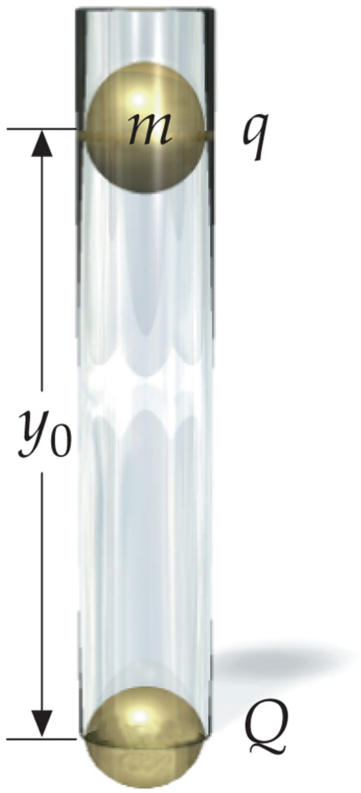


Figure 1: Exercise 1