Universität Leipzig, Fakultät für Physik und Geowissenschaften

Exercises for Experimental Physics 1 – IPSP

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Exercise Sheet 5 (WS 2013/14)

Date of Issue: Nov. 15^{th} 2013

Date of Submission: Nov. 22^{nd} 2013

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, exercises 4 and 5 will be discussed during the seminar.

Exercises:

1. Hydroelectric power plants convert gravitational potential energy into more useful forms by flowing water downhill through a turbine system to generate electric energy. The Hoover Dam on the Colorado River is 211 m high and generates $4 \cdot 10^9$ kW·h/y. At what rate (in L/s) must water be flowing through the turbines to generate this power? The density of water is 1.00 kg/L. Assume a total efficiency of 90.0 percent in converting the water's potential energy into electrical energy. (5 Points)

2. An 80-cm-long pendulum with a 0.60-kg bob is released from rest at an initial angle of θ_0 with the vertical. At the bottom of the swing, the speed of the bob is 2.8 m/s. (a) What is θ_0? (b) What angle does the pendulum make with the vertical when the speed of the bob is 1.4 m/s? Is this angle equal to $\frac{1}{2}\theta_0$? Explain why or why not. (8 Points)

3. Tarzan is in the path of a pack of stampeding elephants when Jane swings in to the rescue on a rope vine, hauling him off to safety. The length of the vine is 25 m, and Jane starts her swing with the rope horizontal. If Jane's mass is 54 kg, and Tarzan's is 82 kg, to what height above the ground will the pair swing after she rescues him? (Assume that the rope is vertical when she grabs him. See Figure 1) (7 Points)

4. You have designed a novelty desk clock, as shown in Figure 2. You are worried that it is not ready for market because the clock itself might be in an unstable equilibrium configuration. You decide to apply your knowledge of potential energies and equilibrium conditions and analyze the situation. The clock (mass m) is supported by two light cables running over the two frictionless pulleys of negligible diameter, which are attached to counterweights that each have mass M. (a) Find the potential energy of the system as a function of the distance y. (b) Find the value of y for which the potential energy of the system is a minimum. (c) If the potential energy is a minimum, then the system is in equilibrium. Apply Newton's second law to the clock and show that it is in equilibrium (the forces on it sum to zero) for the value of y obtained for Part (b). (d) Finally, determine whether you are going to be able to market this gadget: is this a point of stable or unstable equilibrium?

5. Calculate the gradient of the function $f(\vec{r}) = (x_1^2 + x_2^2 + x_3^2)^{1/2}$ with $\vec{r} = \{x_1, x_2, x_3\}$: $\vec{\nabla} f(\vec{r})$.

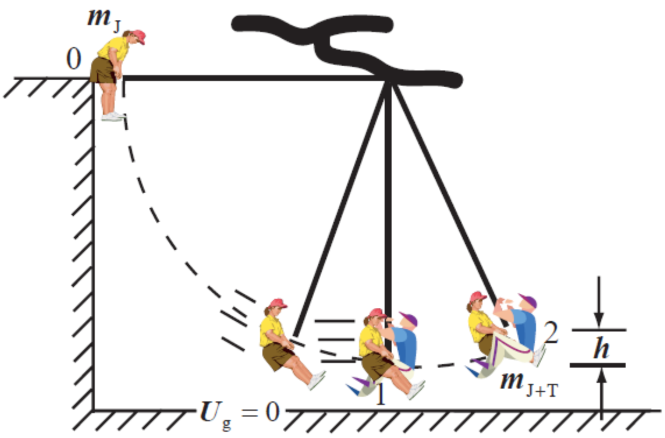

Figure 1: Exercise 3

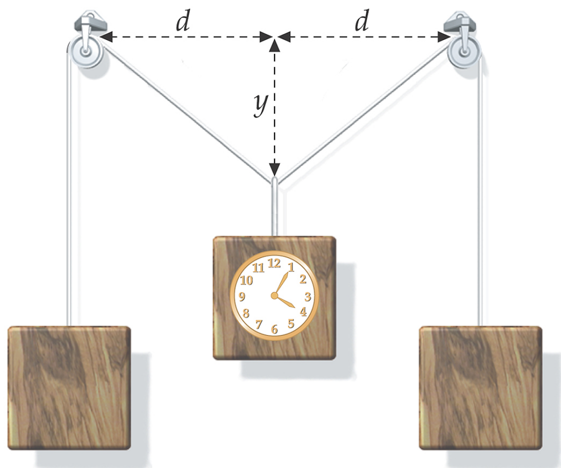

Figure 2: Exercise 4