Universität Leipzig, Fakultät für Physik und Geowissenschaften

Exercises for Experimental Physics 1 – IPSP

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Exercise Sheet 4 (WS 2013/14)

Date of Issue: Nov. th 2013

Date of Submission: Nov. 15th 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. A force F_x acts on a particle that has a mass of 1.5 kg. The force is related to the position x of the particle by the formula $F_x = Cx^3$, where $C = 0.50$ if x is in meters and F_x is in newtons. (a) What are the SI units of C? (b) Find the work done by this force as the particle moves from $x = 3.0$ m to $x = 1.5$ m. (c) At $x = 3.0$ m, the force points opposite the direction of the particle's velocity (speed is 12.0 m/s). What is its speed at $x = 1.5$ m? Can you tell its direction of motion at $x = 1.5$ m using only the work-kinetic-energy theorem (Work $W = E_{kin,final} - E_{kin,initial}$)? Explain. (6 Points)

2. A 7.5-kg box is being lifted by means of a light rope that is threaded through a single, light, frictionless pulley that is attached to the ceiling. (a) If the box is being lifted at a *constant speed* of 2.0 m/s, what is the power delivered by the person pulling on the rope? (b) If the box is lifted, at *constant acceleration*, from rest on the floor to a height of 1.5 m above the floor in 0.42 s, what average power is delivered by the person pulling on the rope? (6 Points)

3. A block of mass m on a horizontal frictionless tabletop is attached by a swivel to a spring that is attached to the ceiling (Figure 1). The vertical distance between the top of the block and the ceiling is y_0, and the horizontal position is x. When the block is at $x = 0$, the spring, which has force constant k, is completely unstressed. (a) What is F_x, the x component of the force on the block due to the spring, as a function of x? (b) Show that F_x is proportional to x^3 for sufficiently small values of $|x|$. (c) If the block is released from rest at $x = x_0$ (where $|\vec{x_0}| << |\vec{y_0}|$), what is its speed when it reaches $x = 0$? (8 Points)

4. When a particle moves in a circle that is centered at the origin and the magnitude of its position vector $\vec{r}$ is constant. (a) Differentiate $\vec{r} \cdot \vec{r} = r^2 =$ constant with respect to time to show that $\vec{v} \cdot \vec{r} = 0$, and therefore $\vec{v} \perp \vec{r}$. (b) Differentiate $\vec{v} \cdot \vec{r} = 0$ with respect to time and show that $\vec{a} \cdot \vec{r} + v^2 = 0$, and therefore $a_r = -v^2/r$. (c) Differentiate $\vec{v} \cdot \vec{v} = v^2$ with respect to time to show that $\vec{a} \cdot \vec{v} = dv/dt$, and therefore $a_t = dv/dt$.

5. Calculate the work along the path C from the following line integral:

$$W = \int_C f(\vec{r})d\vec{r}$$

with

$$\vec{r} = \begin{pmatrix} x \\ y \end{pmatrix} \text{ and } f(\vec{r}) = \begin{pmatrix} 1 \\ 2x \end{pmatrix}.$$

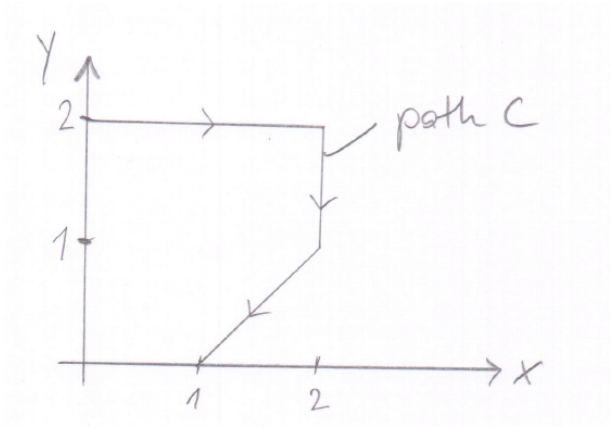

Figure 1: Exercise 5

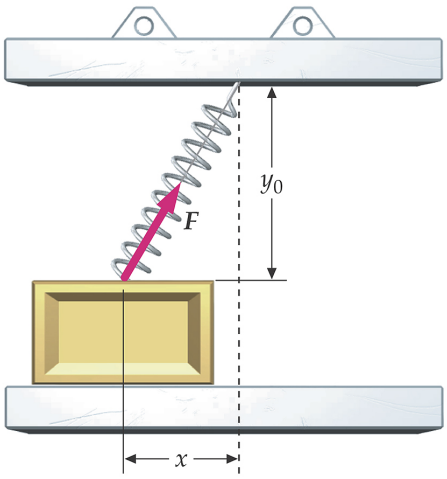

Figure 2: Exercise 3