Universität Leipzig, Fakultät für Physik und Geowissenschaften

Exercises for Experimental Physics 1 – IPSP

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Exercise Sheet 9 (WS 2013/14)

Date of Issue: Dec. 13^{th} 2013

Date of Submission: Dec. 20^{th} 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, exercise 4 will be discussed during the seminar.

Exercises:

1. A bicycle wheel that has a radius equal to 28 cm is mounted at the middle of an axle 50 cm long. The tire and rim weigh 30 N. The wheel is spun at 12 rev/s, and the axle is then placed in a horizontal position with one end resting on a pivot. (a) What is the angular momentum due to the spinning of the wheel? (Treat the wheel as a hoop.) (b) What is the angular velocity of precession? (c) How long does it take for the axle to swing through 360° around the pivot? (d) What is the angular momentum associated with the motion of the center of mass, that is, due to the precession? In what direction is this angular momentum? (7 Points)

2. A large mirror is hung from a nail as shown in Figure 1. The supporting steel wire has a diameter of 0.20 mm and an unstretched length of 1.7 m. The distance between the points of support at the top of the mirror's frame is 1.5 m. The mass of the mirror is 2.4 kg. How much will the distance between the nail and the mirror increase due to the stretching of the wire as the mirror is hung? (7 Points)

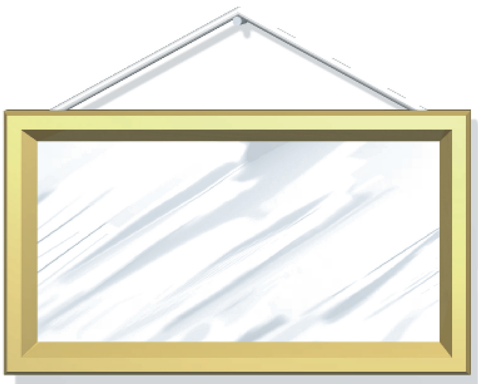

Figure 1: Exercise 2

3. For most materials listed in the table, the tensile strength is two to three orders of magnitude lower than Young's modulus. Consequently, most of these materials will break before their strain exceeds 1 percent. Of man-made materials, nylon has about the greatest extensibility – it can take strains of about 0.2 before breaking. But spider silk beats anything man-made. Certain forms of spider silk can take strains on the order of 10 before breaking! (a) If such a thread has a circular cross-section of radius r_0 and unstretched length L_0, find its new radius r when stretched to a length $L = 10\,L_0$. (Assume that the density of the thread remains constant as it stretches.) (b) If the Young's modulus of the spider thread is Y, calculate the tension needed to break the thread in terms of Y and r_0. (6 Points)

Material	Young's Modulus Y (GN·m^2)	Tensile Strength (MN·m^2)
Aluminum	70	90
Cement	23	2
Tin	16	12
Iron	190	390
Copper	110	230
Brass	90	370
Steel	200	520

4. The term *precession of the equinoxes* refers to the fact that Earth's spin axis does not stay fixed but sweeps out a cone once every 26,000 y. (This explains why our pole star, Polaris, will not remain the pole star forever.) The reason for this instability is that Earth is a giant gyroscope. The spin axis of Earth precesses because of the torques exerted on it by the gravitational forces of the Sun and moon. The angle between the direction of Earth's spin axis and the normal to the ecliptic plane (the plane of Earth's orbit) is 22.5 degrees. Calculate an approximate value for this torque, given that the period of rotation of Earth is 1.00 d and its moment of inertia is $8.03 \cdot 10^{37}$ kg·m^2.