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EXERCISE 10
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Christmas exercises

This exercise sheet contains tasks from the teaching material taught so far. The four marked tasks (*) will be graded and are required to get points for admission to the exam. All tasks are relevant for the exam. The solutions will be announced in the next seminar.
Have a wonderful Christmas and see you in the New Year!

Problem 1: *6 Points

In 1978, Geoff Capes of Great Britain threw a heavy brick a horizontal distance of 44.5 m. Find the approximate speed of the brick at the highest point of its flight, neglecting any effects due to air resistance. Assume the brick landed at the same height it was launched.

Problem 2: *7 Points

The coefficient of static friction between a rubber tire and the road surface is 0.85. What is the maximum acceleration of a 1000-kg four-wheel-drive truck if the road makes an angle of 12◦ with the horizontal and the truck is (a) climbing and (b) descending? Draw a sketch including all important variables and forces.

Problem 3: *6 Points

A homogeneous solid object floats on water, with 80.0 percent of its volume below the surface. When placed in a second liquid, the same object floats on that liquid with 72.0 percent of its volume below the surface. Determine the density of the object and the specific gravity of the liquid.

Problem 4:

A 3.0-kg block slides along a frictionless horizontal surface with a speed of 7.0 m/s (Figure 1). After sliding a distance of 2.0 m, the block makes a smooth transition to a frictionless ramp inclined at an angle of 40◦ to the horizontal.

What distance along the ramp does the block slide before coming momentarily to rest?

Problem 5:

A bullet of mass m_1 is fired horizontally with a speed v_0 into the bob of a ballistic pendulum of mass m_2. The pendulum consists of a bob attached to one end of a very light rod of length L. The rod is free to rotate about a horizontal axis through its other end. The bullet is stopped in the bob. Find the minimum v_0 such that the bob will swing through a complete circle.

Problem 6:

When we calculate escape speeds, we usually do so with the assumption that the body from which we are calculating escape speed is isolated. This is, of course, generally not true in the Solar system. Show that the escape speed at a point near a system that consists of two massive spherical bodies is equal to the square root of the sum of the squares of the escape speeds from each of the two bodies considered individually.

Problem 7: * $3 + 2 + 1$ **Points**

Assume that there is a straight tunnel through the earth connecting the North Pole with the South Pole. An object with a mass of $m = 10^3$ kg is released at the North Pole and falls towards the earth's centre.

a. What is the time needed for the object to reach the South Pole?
b. What is its velocity at the earths centre?
c. Assume that at the centre of the earth the object receives an impulse of 10^4 Ns in the direction of its velocity (i.e. the linear momentum of the object is instantly increased by 10^4 Ns). What is the velocity of the object at the South Pole?

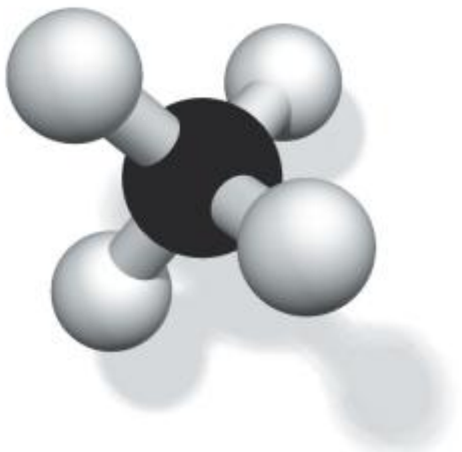
Hint: Assume that the earth is a sphere with a homogenous density. The mass is $m_E = 5.97 \cdot 10^{24}\,kg$, the radius is $6378\ km$.

The gravitational constant is $G = 6.67 \cdot 10^{-11}\,m^3 kg^{-1} s^{-2}$.

Hint 2: It might help to do the following consideration: How does the force depend on R proportionally? What other system works like this?

Problem 8:

The methane molecule (CH4) has four hydrogen atoms located at the vertices of a regular tetrahedron of edge length 0.18 nm, with the carbon atom at the center of the tetrahedron (Figure 2). Find the moment of inertia of this molecule for rotation about an axis that passes through the centers of the carbon atom and one of the hydrogen atoms.



Task to think about:

How important is physics for you? What will you do as a physicist?