KIT - International Department GmbH

Pre-Semester Physics - Exercises Summer 2010

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Sheet 4
18.8.2010

1. Exercise:

An object with mass $m = 27\,\mathrm{kg}$ is pulled along a frictionless horizontal surface by a horizontal force $F = 24\,\mathrm{N}$.

(a) If the object is at rest at $t = 0$ how fast is it at $t = 3.0\,\mathrm{s}$?

(b) How far does it travel during this time?

(c) What distance s would be between its position at $t = 3.0\,\mathrm{s}$ and its original position if it had an initial velocity of $v_0 = 1.0\,\frac{\mathrm{m}}{\mathrm{s}}$ perpendicular to the force?

2. Exercise:

Two masses $m_1 = 2\,\mathrm{kg}$ and $m_2 = 3\,\mathrm{kg}$ are connected by a rope which runs over a pulley. Both masses are exposed to the gravitational force ($g = 10\frac{m}{s^2}$). However, the mass m_1 lies on an inclined plane with angle $\alpha = 30^\circ$ (with respect to the horizontal) while the other one is hanging in the air, $h = 2.0\,\mathrm{m}$ above ground level. Neglect friction!

(a) Determine the acceleration a of the system in terms of g.

(b) Find the time t, the mass m_1 needs to hit the ground.

(c) Find the tension force F_T in the rope.

(d) What ratio of m_1 and m_2 is needed, such that the system stays at rest?

3. Exercise:

Consider the fall of a stone into a lake (due to gravity with $g = 10\,\frac{\mathrm{m}}{\mathrm{s}^2}$): At $t = 0$ the stone with mass $m = 1.0\,\mathrm{g}$ is released at the water surface. There is friction induced by moving through the water with coefficient $\gamma = 1.0\,\frac{\mathrm{g}}{\mathrm{s}}$.

(a) What is the total force F_{tot} on the stone depending on the velocity of the stone?

(b) State the equation of motion.

(c) What would be the final constant velocity $v_{\max}$ the stone could reach?

(d) Prove that the distance traveled in the water as given by

$$x(t) = -10\,\mathrm{m} \cdot \left(1 - t \cdot \mathrm{s}^{-1} - \mathrm{e}^{-t \cdot \mathrm{s}^{-1}}\right)$$

solves the equation of motion.

4. Exercise:

A pendulum consists of a mass point with $m = 2\,\mathrm{kg}$ attached to a rope of length $\ell = 3\,\mathrm{m}$. The mass point is pushed in horizontal direction with a velocity of $v = 4.5\,\frac{\mathrm{m}}{\mathrm{s}}$. Consider the situation at which the rope possesses an angle of $\alpha = 30°$ with respect to the vertical line.

(a) Determine the potential energy difference between both situations.

(b) Find the velocity v'.

(c) Which angle α_{max} does it reach at its highest point?

5. Exercise:

A mass $m_1 = 1\,\mathrm{kg}$ is situated on an inclined plane with angle $\alpha = 30°$. At $t = 0$ it starts moving towards a mass $m_2 = 9\,\mathrm{kg}$ at a distance of $s = 0.4\,\mathrm{m}$ to the first mass and on the same inclined plane. However, the position of the second mass is fixed until both masses collide.

(a) When does the masses collide?

(b) State the velocity v at the time of impact.

(c) What are the velocities v_1', v_2' after the total elastic collision of the two?

(d) Find the height h the first mass reaches after the collision.

(e) Determine the contraction x of a spring with constant $D = 16\,\frac{\mathrm{N}}{\mathrm{m}}$ which the second mass reaches after the collision.

6. Exercise:

Consider again the police car catching a racer. The racer travels at a speed of $v = 72\,\frac{\mathrm{km}}{\mathrm{h}}$ and has a mass of $m_r = 900\,\mathrm{kg}$ while the police car has mass $m_p = 1100\,\mathrm{kg}$ and accelerates with $a = 10\,\frac{\mathrm{m}}{\mathrm{s}^2}$. However, the police car does not break in time and therefore crashes in the racer. After the crash the police car and the racer stick together.

(a) What is the speed of the cars after the crash?

(b) How much energy is lost in the collision?

(c) If the racer would be modeled by a spring with constant $D = 1000\,\frac{\mathrm{N}}{\mathrm{m}}$, how large would be the deformation, i.e. the contraction of the car?

Note:

Consider $g = 10\,\frac{\mathrm{m}}{\mathrm{s}^2}$.