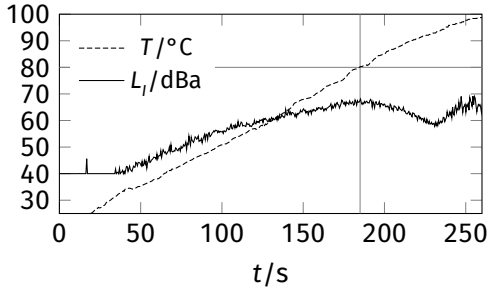
LATVIJAS 49. ATKLĀTĀ FIZIKAS OLIMPIĀDE

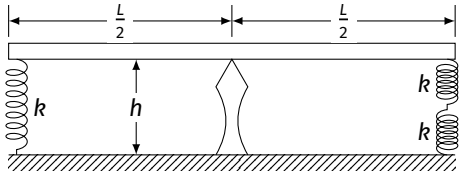
Form 9

9-1° *Kettle* (3 p) While water is being heated up, one can notice that the noise level L_l produced by the kettle increases until the temperature reaches ca. 80 °C and then decreases again (see the plot). Explain why it happens.



9-2° *Stone* (3 p) If a piece of a meteorite attached to a dynamometer, is submerged in water, the dynamometer reads 14 N, but if it is submerged in oil – 16 N. Find the mass and the density of the meteorite piece. Water density 1 $\frac{g}{cm^3}$, oil density 0,8 $\frac{g}{cm^3}$.

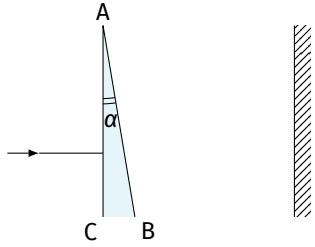
9-3° *Strange scales* (3 p) A uniform plank of length L = 1 m is supported at its midpoint at the height h = 5 cm above the table. Between the table and one end of the plank, a spring of stiffness k = 50 $\frac{N}{m}$ is attached. The relaxed length of the spring is h. Between the table and the other end of the plank, two similar identical springs, connected in series, are attached. How far from the centre of the plank and on which side of the scales does one need to put a mass m = 1 kg, so that the plank remains horizontal?



9-4° *Global warming* (3 p) Two identical cylindrical glasses of cross-section area S = 30 cm^2 contain identical cubes of ice of mass m = 10 g each. Both glasses are filled to half-height: the first one with distilled water (density ρ_0 = 1,00 $\frac{g}{cm^3}$), the second one with salt water (density ρ_1 = 1,02 $\frac{g}{cm^3}$) so that ice cubes do not touch the bottom of the glass. After some time ice melted in both glasses. Explain how the water level will change and determine the water level difference between the glasses when ice will have melted.

9-5° *Goldfish* (3 p) A pot of volume V_t = 2 ℓ is filled up to brim with water at temperature T_0 = 10 °C. A gold rod with temperature T_1 = 70 °C is then placed in the pot, and some water has flown out of the pot. After some time, temperatures of the rod and water equalised at T = 20 °C. Determine the equilibrium temperature of water, if not one but two such gold rods were placed in the pot. Specific heat capacity of water c_0 = 4,2 $\frac{J}{g°C}$ and density ρ_0 = 1 $\frac{g}{cm^3}$. Specific heat capacity of gold c_1 = 0,13 $\frac{J}{g°C}$ and density ρ_1 = 19,3 $\frac{g}{cm^3}$. Neglect heat exchange with the environment.

9-6° *Maximal refraction* (4 p) A narrow laser beam is normally incident onto the side face AC of a straight prism, the base of which is a right-angled triangle (see fig.). How many bright points will be seen on a screen, which is located behind the prism and is parallel to the face AC? Refraction index of glass n = 1,41, angle α = 10°. Assume that the length of the face AC and the screen are very large.



9-7° *Weak heater* (3 p) A vessel is filled with water at temperature T_0 = 20 °C. The water is to be heated up with an immersive heater (metal spiral), the resistance R of which changes with temperature T in such a way that $R = R_0[1 + \alpha(T - T_0)]$, where α = 0,1 $\frac{1}{°C}$ and R_0 = 100 Ω. Assume that temperatures of the heater and water are equal at any time. The vessel is not insulated, and each second energy $Q = \beta(T - T_0)$ is lost to the environment, where β = 2 $\frac{J}{°C}$. The heater is connected to a current source, which ensures constant current I = 0,2 A in the heater. Determine the maximal temperature T_{max} of water that can be achieved.

9-8° *Strings and units* (3 p) Oscillation frequency of a string depends only on its diameter D, density ρ and tension force F. One of the nylon guitar strings was replaced with a nickel string of 1,5 times smaller diameter. By what factor should the tension force be increased for the frequency to remain the same? Nylon density ρ_1 = 1240 $\frac{kg}{m^3}$, nickel density ρ_2 = 8900 $\frac{kg}{m^3}$.

9-9° *Winter delights* (2 p) A boy on a sled slided with constant velocity down the shallow ice slope, which makes an angle $\varphi = 1°$ with the horizontal. At the end of the slope it turned out that the rails of the sled were $\Delta T = 0{,}5\,°\mathrm{C}$ warmer than at the beginning of the descent. The total mass of the boy and the sled is $M = 70\,\mathrm{kg}$, the rails are made of steel of specific heat capacity $c = 420\,\frac{\mathrm{J}}{\mathrm{kg}\,°\mathrm{C}}$ and their net mass $m = 0{,}75\,\mathrm{kg}$. Assume that the rails absorb $\eta = 40\,\%$ of the total released heat. Free fall acceleration $g = 10\,\frac{\mathrm{m}}{\mathrm{s}^2}$.

(a) Determine the friction force that acts on the sled during the ride.
(b) Determine the length of the slope.

9-10° *Multiple choice questions* (3 p) For each question there is one correct answer. Justify your choice. Answers without justification will receive zero marks.

(1) Gravity on Mercury is K times smaller than on Earth. A ball dropped on Earth from height h takes time t to reach the ground. From what height should it be dropped on Mercury so that it takes the same time t to reach the surface? Neglect air resistance.

(a) h/K^2
(b) h/K
(c) h
(d) hK
(e) hK^2

(2) A block of brass (an alloy of density $8730\,\frac{\mathrm{kg}}{\mathrm{m}^3}$) has sides of length 3 cm, 4 cm and 5 cm. What is the maximum pressure that can be exerted by this block when it is placed on a table on one of its faces?

(a) 4,28 kPa
(b) 428 kPa
(c) 3,43 kPa
(d) 257 kPa

(3) An astronaut in the International Space Station experiences weightlessness because...

(a) she is outside the Earth's gravitational field;
(b) the attraction force of the Moon cancels out that of the Earth;
(c) the attraction force of the Sun cancels out that of the Earth;
(d) she is accelerating at the same rate as the space station.

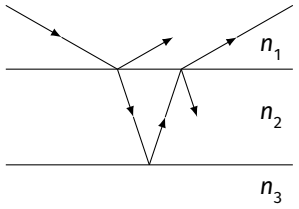
(4) A lift is moving upwards at a constant speed. Ignoring any friction, which statement is correct?

(a) The kinetic energy of the lift is constant.
(b) The gravitational potential energy of the lift with respect to the ground is constant.
(c) The mechanical energy of the lift with respect to the ground is constant.
(d) Statements(a) and (c) are both correct, but (b) is not correct.
(e) Statements (a), (b) and (c) are all correct.

(5) A drop slide in a fairground has a steep initial slope which gradually curves into a more gentle slope. If a child drops down the slide, what happens to his speed v and the magnitude of his acceleration a, ignoring any friction forces?

(a) v and a both increase.
(b) v increases, a does not change.
(c) v increases, a decreases.
(d) v decreases, a increases.

(6) Light rays propagate through three media of refractive indices n_1, n_2 and n_3, respectively, as shown in the diagram. Which of the following statements is correct?



(a) $n_1 < n_2 < n_3$
(b) $n_2 < n_1 < n_3$
(c) $n_1 < n_3 < n_2$
(d) $n_3 < n_1 < n_2$
(e) $n_3 < n_2 < n_1$