For each problem the recommended grades are specified in the parentheses (a student is allowed to solve the problems for older grades; if a student solves a problem intended for younger grades, the solution will be ignored).

Task 1. (5–7 gr.)

Tom made several small ice chips of different shapes, put them into a glass and noted the level of the top of the ice chips. Then he poured a little water into the glass thinking that the ice would start floating in the water and this level would rise. However, despite his expectations, the level of the ice chips became lower! How could this be explained?

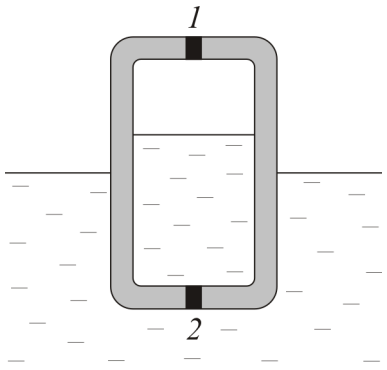
Task 2. (5–8 gr.)

Tom, Will and Henry were riding their bicycles together and going quite fast. Tom was holding the handlebars with both hands, Will with just one and Henry was riding "no handed". At one point they all had to stop quickly. Tom and Henry managed to keep their balance despite the sudden stop, but Will tumbled to the ground. Explain why did this happen to him only. All the bicycles are identical, and all the boys used coaster brakes - the ones that stop the rear wheel if the pedals are rotated backwards.

Task 3. (5–8 gr.)

A star is orbited by two planets. The planets' orbits are circular and lie in the same plane. The orbital period (the time a planet takes to make a complete circle around the star) of one planet is 1 Earth year, and the orbital period of the second planet is 0.8 Earth years. At a certain time the distance between the planets was the smallest possible. How long would it before the distance between the planets becomes the largest possible?

Task 4. (7–8 gr.)

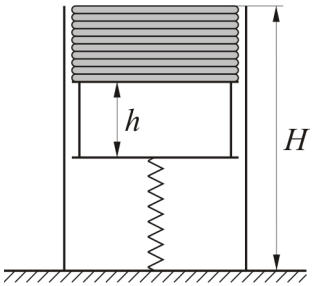


A cylindrical vessel floats in a large pool of water. There are two small holes in it, one in the top and one in the bottom, each closed by a stopper. There is water in the vessel, its level is shown in the picture. The air pressure inside the vessel is equal to atmospheric pressure. The holes are then opened one after another. Describe, how the level of the water inside the vessel and the depth of the vessel inside the pool would change after each hole is opened if

a) First stopper 1 is removed and then stopper 2;

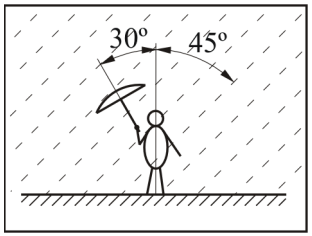
b) The order is reversed.

Task 5. (8–10 gr.)



You need to make a magazine stand. The magazines are placed on a light plastic platform, which rests on a vertical spring. The other end of the spring is fixed at floor level. The stand should have the following property: the top magazine of the pack placed on it should be at a height $H = 0{,}8$ m from the floor, independent of the size of the pack (up to some limit, naturally). The mass of each magazine $m = 0{,}2$ kg, its thickness $d = 5$ mm. You have a spring of length $l_0 = 1$ m, with a spring constant $k_0 = 200$ N/m. What length l do you need to cut from it to use in the magazine stand? What the thickness h of the plastic platform should be? The masses of the spring and the platform are negligible.

Task 6. (9–11 gr.)



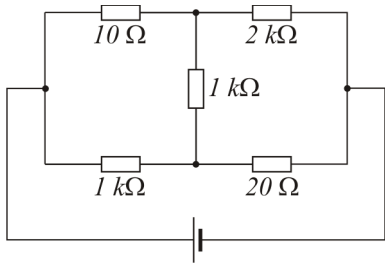
A train passenger looks out of the window and sees that it is raining outside and that the raindrops fall at an angle of 45° to the vertical. The train goes by a platform and the passenger notices that all the people standing on it have their umbrellas inclined by 30° in the direction of the rain and not across it (see picture)!

a) What is the direction of the wind (in reference to the ground) and which direction is the train moving in (to the right or to the left of the picture)?

b) Find the speed of the train if the speed of the wind is 10m/s.

In your solution presume that the people on the platform are sensible and have no intention of getting wet.

Task 7. (9–11 gr.)



In the circuit shown on the schematic the voltage of the battery is 10 V. Find the (approximate) voltage across the 10 Ohm resistor.

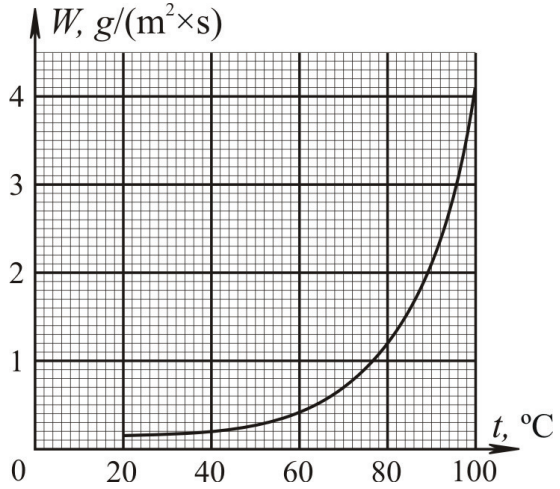
A footnote: An exact value for this voltage can be found by solving a bulky set of equations. You need to find a very short and easy way to calculate the voltage approximately (to get an answer within several percent of the exact value).

Task 8. (10–11 gr.)

An ordinary balloon is weighed empty, then inflated with air and weighed again. The weight of the balloon increased by 0.1 g. Estimate the overpressure in the balloon(the difference between atmospheric pressure and the pressure inside). Conside everything to be at room temperature and estimate the size of the balloon. The gas constant R ≈ 8,31 J/(mol×K).

Task 9. (9–11 gr.)

1 litre of water at 20°C was placed in an insulated Thermos-pot, then an immersion heater of power P was placed inside an turned on. The pot is not covered by a lid, so the water evaporates as it is heated. The graph shows the dependence of the rate of evaporation (the mass of water that evaporates from unit surface area every second) on the temperature of the water. The water surface area of the pot is 200cm^2, the latent heat of evaporation of water is 2290 kJ/kg, its specific heat is 4200 J/(kg°C).



a) The immersion heater is very weak, $P = 50$ W. Find the maximum temperature the water will reach over a long time period.

b) $P = 200$ W. Estimate the time required for the water to boil.

c) $P = 1$ kW. Find the approximate mass of water that would evaporate before the water starts boiling.

Consider the heat capacity of the pan and the heat conduction through its walls to be negligible.

Task 10. (9–11 gr.)

Read "The Quarks" and do the following tasks:

a. There is a table of quark compositions and electrical charges of three particles (e is an elementary electrical charge). According to this find the charges of **u**-, **d**- and **s**-quarks. Your solution must be demonstrated, it shouldn't be just "guessing".

Particle	proton	neutron	kaon (K^+-meson)
Quark compound	**uud**	**udd**	**u$\bar{\text{s}}$**
Electrical charge	$+e$	0	$+e$

b. A pion (π^+-meson) has a quark composition **u$\bar{\text{d}}$**. How many ways are there to "colour" the quarks in this particle? Give the entire list.

c. In July 2015 at the Large Hadron Collider a pentaquark (a particle consisting of five quarks) was detected. How many actual quarks can be in this particle, and how many antiquarks? Give all the variants (do not mention flavours and colours, only numbers), show your solution.

Don't forget to **sign** your work (please, write the card number, your last name, school and grade) before **submitting** the work. You do not have to submit the sheet with the tasks. The tasks, their solutions and the results of the competition will be published at *http://turlom.olimpiada.ru* after November 20.