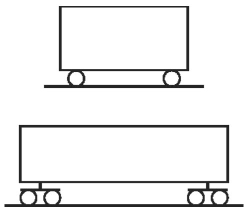
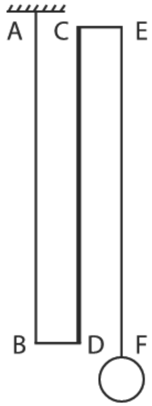
For each problem the recommended grades are specified in the parentheses (a student is allowed to solve the problems for older grades; if a student solves a problem intended for younger grades, the solution will be ignored).

Task 1. (5–7)



In the 19th century railway carriages had two wheelsets — each one had four wheels firmly attached to two axles. Most modern carriages have four wheelsets. Their axles are not connected to the body of the carriage, but instead each pair is attached to a chassis, forming a small trolley beneath each end of the carriage. Each trolley can rotate in relation to the carriage around a vertical axis. Why are modern carriages produced this way? State two reasons (or at least one). *(5 points)*

Task 2. (5–8)



Most materials expand when heated and contract when cooled down. This phenomenon prevented the creation of a precise mechanical clock, because the length of the pendulum changed with temperature, affecting the rate of the clock. In the 18th century a new construction of a pendulum was invented — one that did not expand with heat. It consists of three metal rods connected like it is shown in the picture. The side rods (AB and EF) are made of the same metal, while the central rod (CD) — of a different one. How many times should the expansion of the central rod differ from the expansion of the side rods when heated, in order to preserve the length of the pendulum? *(5 points)*

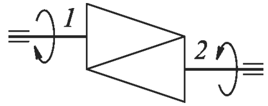
Task 3. (5–8)

A boy stands in front of a mirror, shuts his left eye and closes its image by putting his finger on the mirror. Then he opens his left eye and shuts his right one. What will he see in the mirror? What will his finger be closing? Explain your answer with a diagram. *(5 points)*

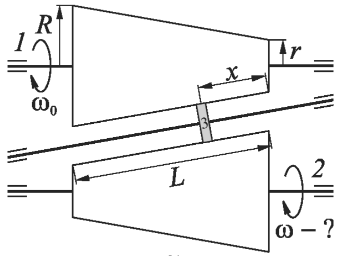
Task 4. (8–9)

The mass of a ship is 1600 tons. Its length (from the bow to the stern) is 100 m and its width (the maximum distance between the sides) is 20 m. Can this vessel pass through a canal 7 meters deep, or will it necessarily ground? Explain your answer. The density of water is 1000 kg/m^3. *(5 points)*

Task 5. (8–10)



a)



b)

In 1986 a problem was given on the entrance exam to MIPT where a friction mechanical transmission was mentioned. The rotation of a drive shaft 1 was transmitted to a driven shaft 2 by the friction between two same truncated cones evenly pressed to each other along the generatrix (*a*).

Such a transmission is never used in real life. Though there are similar devices, such as *frictional variator (b)*. The rotation of a drive shaft 1 is transmitted to a driven shaft 2 by two same truncated cones with an intermediate roller 3. This roller can be moved along the axis of its rotation to change the rotation velocity of a shift 2 without changing the velocity of a shift 1.

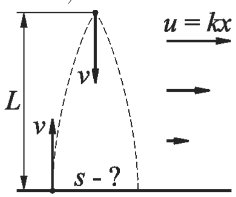
a) Why is the transmission *(a)* never used in real equipment? Which disadvantage is the cause?

b) Which parameter (size) in the construction of friction variator should be small (and compared to what) so that this device almost doesn't have this disadvantage?

c) Find an angular velocity of a driven shift if a roller is set to a position shown on the picture. An angular velocity of a drive shift is ω_0, a driven shift isn't loaded (it rotates freely). *(8 points)*

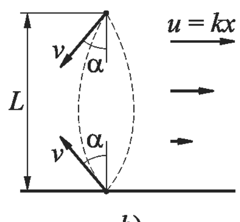
Task 6. (9–11)

The velocity of a river flow u near the bank is directly proportional to the distance from the bank x: $u = kx$ (k — some known coefficient).



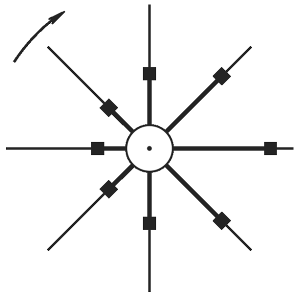
a)

a) A swimmer starts in some point of the bank and swims with a velocity v in relation to water, directing this velocity perpendicularly to the flow. As soon as he has moved from a bank to a distance L he turns round and swims backwards (with the same velocity v perpendicular to the flow). How far from the starting point will he get out from the water?



b) In order to prevent being washed downstream the swimmer made some changes to his routine. He turned his velocity (in relation to water) by some angle α to its initial direction (against the flow). On his way back he turned it again, also against the flow. Find this angle α if he got out of the water in the starting point. *(8 points)*

Task 7. (9–11)
An inventor proposed a fundamentally new idea for a spacecraft engine. A spaceship of his construction is cylindrical with a number of long rods protruding radially out of it. All the rods are equipped with equal weights that can be moved along the rods using telescopic manipulators. The whole craft is put in rotation, and after that the weights are moved by the manipulators in such a way that they are further away from the craft for one half of their trajectory (the right half of the picture, for instance) than for the other half. The inventor believes that as the centrifugal force is proportional to the centripetal acceleration $a_c = \omega^2 r$, the weights on the right would provide a greater pull off the body of the craft than the weights on the left. As a result, the craft would experience a total force acting to the right and start to accelerate.



a) Will this engine work, if built? Provide arguments to support your opinion.

b) If you believe that it will not — explain what is wrong in the inventor's logic. You have to find a mistake in the reasoning — references to general laws of Physics belong in the previous section. *(8 points)*

Task 8. (9–11)
An unexperienced pupil connected an ammeter (a device with very small internal resistance) directly to a high-power voltage source. As a result the device carried a current of 20 A. The ammeter has a fuse — a meltable insert, where a current flows through a thin copper wire 20 mm length and with a section area of 0,01 mm^2. If a current is hazardous for the ammeter the fuse melts and breaks the circuit. Will the fuse melt and protect the ammeter or will the ammeter get burnt sooner? The ammeter can withstand such a current for 0.02 s.

Specific heat for copper is 390 J/(kg $\times$ deg), latent heat of fusion $2,13 \times 10^5$ J/kg, its density is 8900 kg/m^3, electrical resistivity $1,7\times10^{-8}$ Ohm$\times$m, temperature of fusion is 1080°C. The initial temperature of the fuse is 20°C. *(8 points)*

Task 9. (10–11)
Estimate the minimum velocity of the wind when it is able to knock over a bus. *(8 points)*

Task 10. (10–11)
Choose the greatest physical breakthrough of the 20th century in your opinion and tell your younger brother (curious and thoughtful student starting secondary school) what it is about and why is it the greatest. Write a short (1-3 pages) text. *(10 points)*

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.