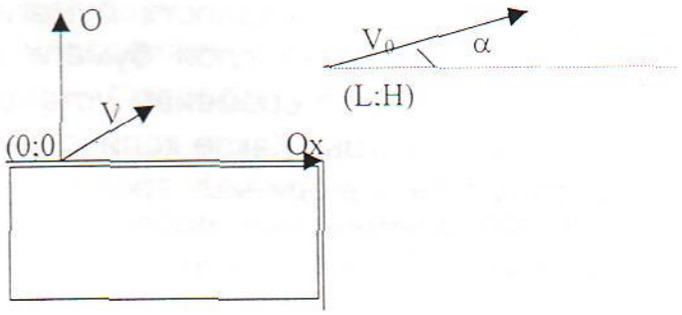
ФИЗИКА

PHYSICS

Higher league. Theoretical competition

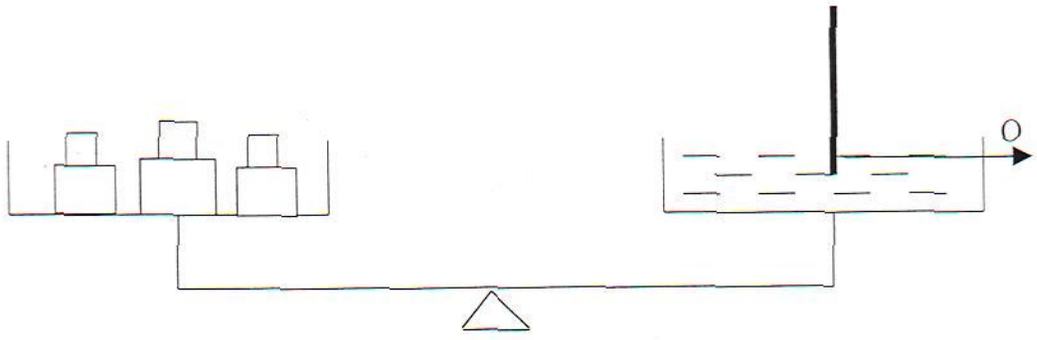
1. A stone is thrown from the point with coordinates (L,H) at moment t . Its speed is V_0, and its velocity is directed under the angle α to horizon. The initial point lies exactly above the edge of precipice of infinite depth.



What minimum speed should the other stone thrown at the same moment from the point (0,0) have in order to meet the first stone and what angle to the horizon should it be thrown at if it is known that:
L=H=10 m, V_0=10 m/sec.

1a) $\alpha = 0°$
1b) $\alpha = 60°$?

2. A vessel with water is balanced on the scales with equal arms. A plate of width L is put into the vessel so that it does not touch the walls of the vessel. The angle of contact θ, surface tension coefficient of water is σ. The plate is wide enough to neglect the effects on its end faces. Consider the system of coordinates so that the axis Oy is vertical and the axis Ox is horizontal and perpendicular to the plate.

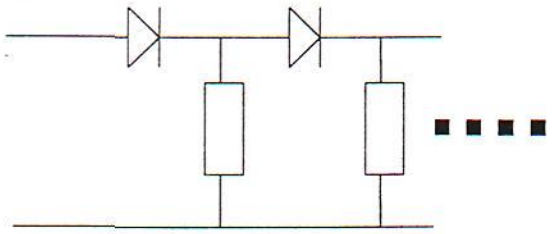


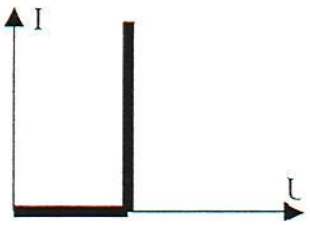
2a) Estimate mass of the weight that should be removed from the pan to restore the equilibrium.

2b) Find the height of water raising just near the plate with respect to the undisturbed level of water.
2c) What is the shape of the water surface y (x) near the plate?

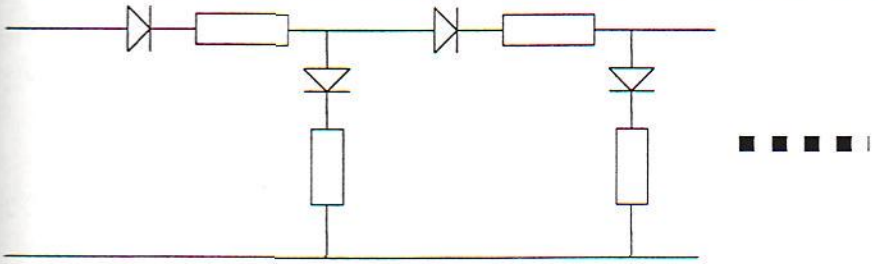
3. In this problem you should investigate circuits containing non-linear elements.

3a) An infinite circuit (see fig.) is constructed of resistors with resistance R and diodes with voltage-current characteristic shown in the figure. Find the voltage-current characteristic I(U) of this circuit in the case $U >> \Delta U$.





3b) The circuit shown in the figure consists of N sections. All elements of a circuit have the same parameters as in the previous question.

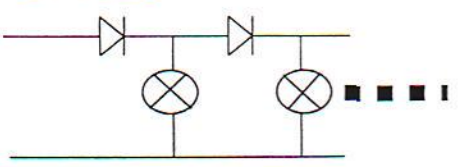


The current through the last section is I_0. Find the current through the whole circuit and voltage on it.
Note. The formula of the n-th term of Fibonacci sequence (a1=a2=1, aN+2=aN+aN+1) is

$$a_N = \frac{\left(\frac{1+\sqrt{5}}{2}\right)^N - \left(\frac{1-\sqrt{5}}{2}\right)^N}{\sqrt{5}}$$

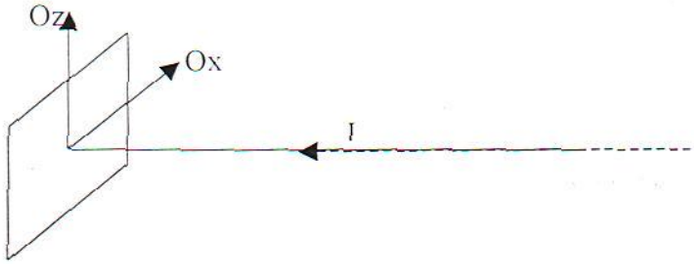
3c) We complete the circuit described in the question 3b) to an infinite circuit. Using the solution of the previous question (for a circuit with finite number of sections) describe a way to construct the voltage-current characteristic of an infinite circuit in the case $U >> \Delta U$.

3d) Draw the voltage-current characteristic of an infinite circuit consisting of diodes and bulbs (see a fig.). Voltage-current characteristic of the diode and the bulb are



given on a separate sheet * and are denoted U_D and U_L.
Note. The characteristic of a circuit should be drawn on the same sheet and returned together with the your work.

4. There is an infinite conducting plate in the plane y=0 (Cartesian coordinates). Semi-infinite straight thin wire going along the axis Oy (y>0) is connected with the plate. Direct current I flows through the wire.



4a) Find the field B(x,y,z) in the space.

4b) At the initial moment a particle with mass m and charge q is located at the point (0, y, r) and moves with velocity (0, v_0,0). Find the minimum and the maximum distances between the particle and the wire during the movement.
4c) At the initial moment a particle with mass m and charge q is located at the point (0, y, r) and moves with velocity (v_x, v_y, 0). Find the velocity of the particle and the distance between the particle and the wire at that moment when velocity of the particle is perpendicular to axis Oy.

4d) The initial data is the same as in the question 4b). Find average velocity of the particle for the large time (drift speed), if it is known that

$$\frac{mV}{\mu_0 eI} << 1$$

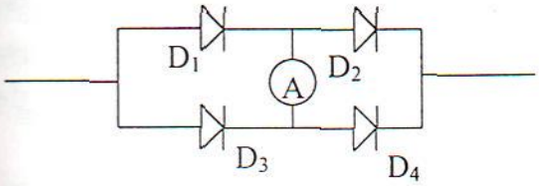
Experimental competition

The task: Determine the circuit of "black box" and parameters of its elements.

The equipment: "black box", battery, multimeter, ammeter, connecting wires, rheostat (potentiometer), section paper.

1. Two stones are thrown from one point at the moment t=0 with the same speed V_0 under angles α and 2α to horizon respectively. The stones move in a vertical plane. A photograph of these two stones is made at the moment τ. The stones in this photo look like two short parallel lines. The camera is motionless, its axis is perpendicular to the plane of stones motion. Find τ. Neglect the air resistance.

2. There are 4 diodes in the circuit represented in the figure. The current through the ammeter does not flow at any voltage supplied to the circuit. **Voltage-current characteristics** of three diodes D1, D2 and D3 are given *. Draw the voltage-current characteristic of the fourth diode.



Note. Voltage-current characteristics of diodes D1, D2 and D3 are given on a separate sheet. The voltage-current characteristic of the diode D4 should also be represented on this sheet and returned together with your paper.

3. In this problem you should investigate flat movement of an absolute solid. Four points A, B, C and D* are marked on a solid.

d) Instantaneous velocity $\bar{V}_A$ of a point A and direction of instantaneous velocity $\bar{V}_B$ of a point B are known. Find instantaneous velocity $\bar{V}_C$ of a point C.

e) Instantaneous velocity of a point A and instantaneous speed of a point B are known. Find instantaneous velocity of a point C.

f) Instantaneous velocity of a point A is known. Instant speeds of points B and C equal to each other. Find velocity of point D.

Note. Locations of the points on solid and their velocities are specified on a separate sheet. Draw the required velocity vectors on the same sheet.

4. Many identical coins are put close to each other by their flat sides. They are divided by round paper pieces of the same diameter as the coins. The

long cylinder thus obtained is twice wrapped in paper. One of end faces of this cylinder touches a thermostat and has constant temperature T_1. A paper piece of thickness h is placed between the thermostat and the coin closest to it. The cylinder is put in air of temperature T_0. Heat conduction of coins is much greater than that of the paper. Diameter of a coin is d, thickness of coin is H. Thickness of the paper is h ($h << d$).Heat conduction of paper is λ. Presently stationary distribution of temperature is established. *What amount of heat receives the cylinder from thermostat at the unit of* time?

Experimental competition

When an external force acts on a body, it changes its form. There are elastic and non-elastic deformations. Draw the diagram of deformations of a rubber rope depending on acting force. Specify areas of elastic and non-elastic deformations.

Equipment: the rubber rope, strong string, two stands, weight, dynamometer, *ruler, section paper.*