All Russian Olympiad in Physics 2016-17
Final Round: Grade - 10

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Problem 1. "On An Ice Floor"

There is a boy on the bank of the river and there is a heavy ice floor with a rectangular shape and a flat horizontal surface. It swims with a constant velocity v_0.The boy pushes a stone of mass m glide over the surface of the ice from its edge.The initial velocity of the stone is equal to the speed of the ice and is directed at an angle $\alpha = 60^\circ$ to coast. (as shown in Figure 1)

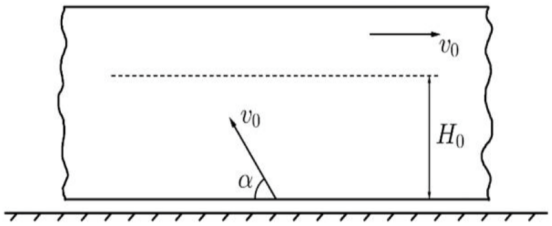

Figure 1: Problem 1

The boy noticed that when the stone was at a distance h from closest edge of the ice, the speed of the stone was minimal.

- How much heat Q was released during sliding of the stone on the ice floor?
- At what distance s from the boy on the river bank will the stone be at the moment of its sliding's end on the ice?

Problem 2. "Separate Departure"

The horizontal speed u was given to two identical balls with radius r. The balls are moving in lower part of the U-shaped fixed tube(Figure 2). The distance between "legs" of this tube is $h = 1.00$ m, there is no friction in the system and gap between balls and tube is negligible.
What should velocity u be that one ball will leave tube from upper part of tube, but other one will leave from lower part? Acceleration due to gravity is g.

Problem 3. "From The Archive of Lord Kelvin"

One day, examining the archive of Lord Kelvin, physicist Buck discovered a graph (see Figure 3) and an explanatory note from Kelvin that revealed that he had studied isochoric processes. Because of time, ink faded and the coordinate axes disappeared from the graph, but a note about the last point of

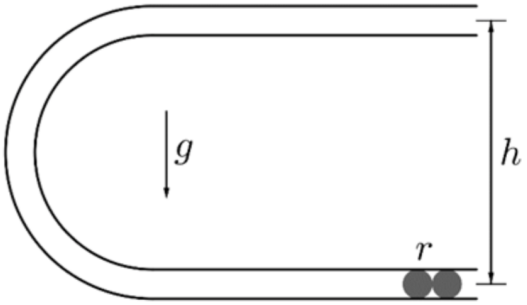

Figure 2: Problem 2

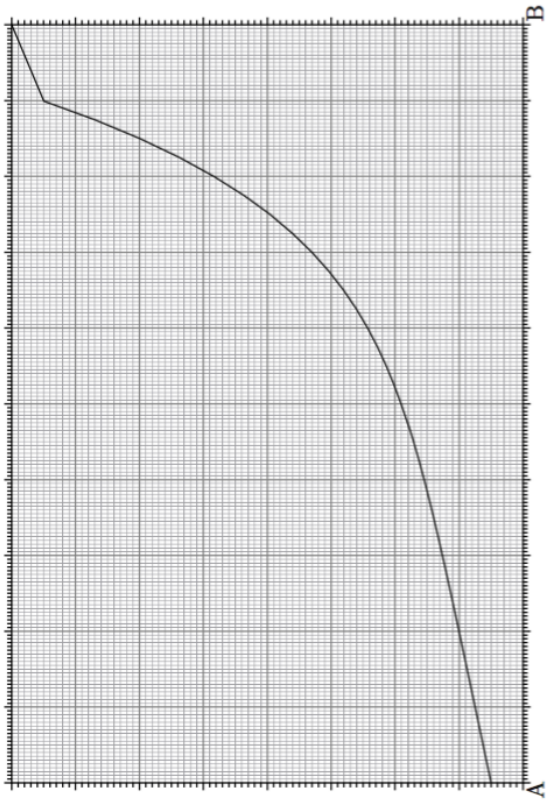

Figure 3: Problem 3

graph survived, having corresponding pressure $p = 2000$ mmHg and temperature 127°C. The walls and balls are small. Buck realized that graph shows dependence of the pressure of the contents of vessel on temperature and there was some other substance in addition to the air present that underwent a phase transition. To find out what the substance was, Buck calculated the saturated vapour pressure of this substance at the point indicated by the shown question mark.

- What was this substance?
- What is the pressure and temperature at the point indicated by the question mark? Justify your answer. Find the temperature of contents of vessel when 30% of all the liquid in the vessel has evaporated.

Problem 4. "A Bridge with Diodes and Capacitors"

Electrical circuit (Figure 4) consists of three identical (and ideal) capacitors with a capacitance $C_1 = C_2 = C_3 = C$, two identical diodes, two ideal ammeters, a switch and a adjustable source of voltage. The dependence of current on voltage is as shown in Figure 5.

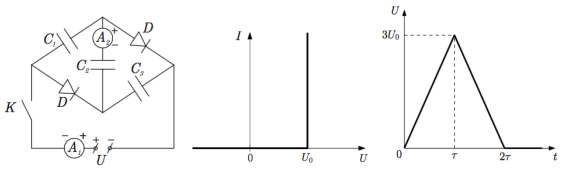

Figure 4: Problem 4

- Let the voltage from source be $3U_0$. How much heat will release when we close switch **K**?
- Let the voltage from source be $U = U(t)$ as shown in Figure 6. The switch **K** always remains closed. Find the dependence of currents $I_1(t)$ and $I_2(t)$ in ammeters A_1 and A_2 with time. Sketch a graph that indicates $I_1(t)$ and $I_2(t)$ with showing characteristic points on the graph. Source polarity and polarity of ammeters are shown in Figure 4. In all cases the initial charge of capacitors are 0.

Problem 5. "Ohm-m-m..."

Electrical circuit (Figure 7) consists of the same ohmmeters and a resistor with resistance $R = 1\ k\Omega$. All

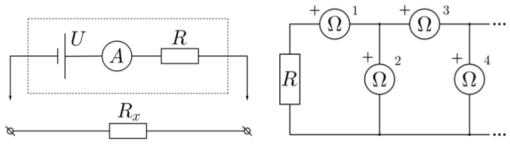

Figure 5: Problem 5

ohmmeters are connected in such a way that for devices with an odd number the terminal marked with a plus sign is on the left, and for even is on the top. Find the readings of first, fourth and thirteenth ohmmeters.

Note: Consider an ohmmeter consists of an ideal constant voltage source U, a resistor with resistance $R = 1\ k\Omega$ and a ideal ammeter connected in series(Figure 8). When a resistance connect to ohmmeter, it calculates its resistance according to value on the ammeter. So if we connect some R_x (as in Figure 8), the ohmmeter's reading will display a value of R_x.