All Russian Olympiad in Physics 2018-19
Grade - 10

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Problem 1. On a smooth horizontal table lies a dumbbell, consisting of two point-sized balls having masses m_1 and m_2 connected by a light rigid (rod deformation can be considered small compared to its size) rod of length L. At time $t = 0$, a constant horizontal force F begins to act on the ball of mass m_1. The vector of the applied force always makes the same acute angle α with the rod (see Figure 1). Consider that in such a motion, the angular acceleration of the rod remains constant. At some time τ from the beginning of the motion, the rod turned out to be completely unstressed for an instant (i.e., neither compressed nor stretched).

1. Find the angular velocity ω of the rotation of the rod at time τ.
2. Find the angular acceleration of the rod $\frac{\mathrm{d}\omega}{\mathrm{d}t}$.
3. What is the time interval $t = \tau$?
4. Find the angle the rod has rotated by at time $t = \tau$.

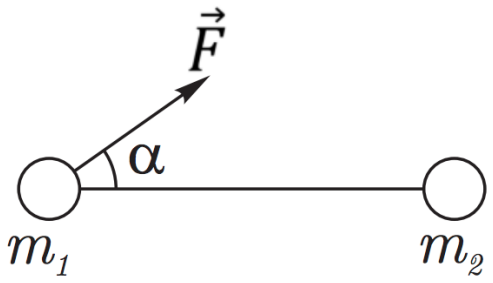

Figure 1: Problem 1

Problem 2. Two small particles with the same masses m and opposite charges q and $-q$ move without friction along narrow straight channels intersecting at right angles located in the horizontal plane (see Figure 2). In the process of motion, the distance between the particles remains unchanged and equal to R at all times. Find the total kinetic energy of the particles.

Problem 3. In Lord Kelvin's archived notes, the description of a cyclic process over a fixed amount of mono-atomic ideal gas was found (see Figure 3). From time to time, the ink faded, and information about the direction of some processes was lost. Information about what was plotted on the abscissa was also faded. It is now only known that one of the following quantities is present on the x-axis: volume,

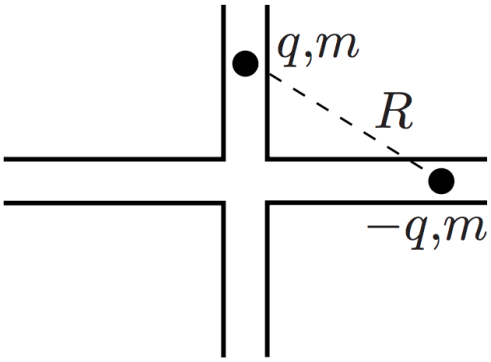

Figure 2: Problem 2

pressure, temperature or density, and the scale of this quantity may be in any units. The molar heat capacity of gas C is plotted along the ordinate. Find the maximum possible efficiency of this cycle.

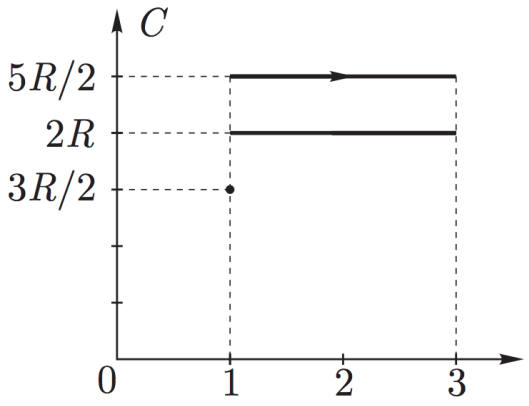

Figure 3: Problem 3

Problem 4. A thin flat diamond-shaped dielectric plate with side a and an acute angle 60° is charged uniformly with a surface charge density σ. The potential at the top of the sharp corner (the acute angle) of the rhombus is equal to ϕ_1, and the potential at the top of the obtuse angle is ϕ_2 (see first object in Figure 4). The thin plate in the form of a dielectric is cut from equilateral triangle $\triangle ABC$ with side $2a$ is charged with the same surface charge density (as shown).

1. Determine the potential at point C of the triangular plate.
2. Determine the potential at point D lying on the middle of the side of the triangular plate.

Now the right triangle is removed from the triangular plate ABC with side a (see third object in Figure 4). Call this triangular plate "holey".

3. Determine the potential at point D' of the "holey" plate.
4. Determine the potential at point C' of the "holey" plate.

Note: All plates are removed from each other and other bodies.

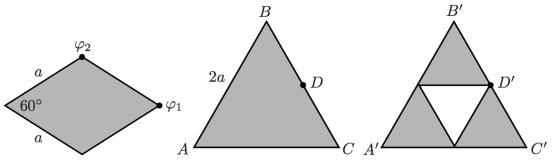

Figure 4: Problem 4

Problem 5. An infinite grid with identical square cells is assembled from identical resistors. A current I flows into node A from the outside as shown. Estimate the current strength in the BC link with an error of no more than 10%. Prove that the error in your calculation does not exceed 10%.

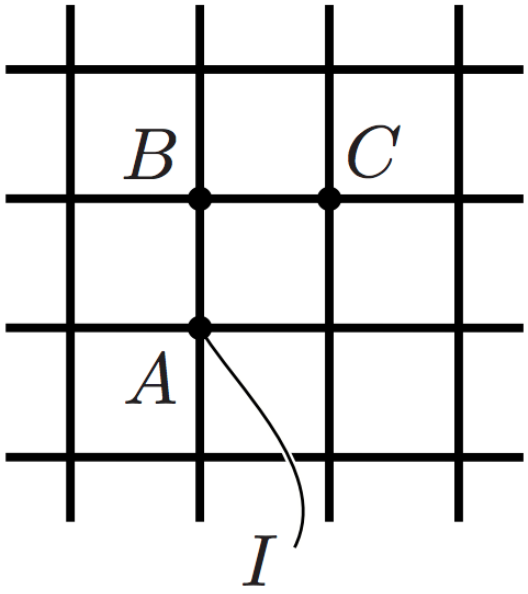

Figure 5: Problem 5