РКЦ Российский Квантовый Центр

HIGHLAND GOLD

Кубок V ЛФИ

10.s05.e03

Hint 2

IMPORTANT! The next task is both a hint and an alternative to the main task. Three important points:

1. You can continue to send the solution to the main problem.
2. At any moment before the final deadline you can start to solve the Alternative problem. If you do so, at the beginning of the solution write: *I am doing the Alternative problem!* In this case a penalty coefficient for the Alternative problem is

$$0{,}7 \cdot \sum_i \frac{k_i \cdot p_i}{10},$$

   where p_i is a point for the problem item, and k_i is a penalty coefficient for the corresponding problem's item at the moment of moving to the Alternative problem. In other words, maximal points for the alternative problem equals to the maximal points you can gain at the moment of moving to the alternative one multiplied by 0,7. Also, we remind you that a penalty coefficient can't be less than 0,1. Solutions of the main problems from that moment will not be checked. Be careful!
3. The task consists of several items. The penalty multiplier earned **before** is applied to all points. In the future, each item is evaluated as a separate task. If you send a solution without any item, this item's solution is considered as Incorrect. For more information about scoring points for composite tasks, see the rules of the Cup. **Since switching to an alternative selection, there is no opportunity to return to solving the main task.** Also, after switching to an alternative task **the points for the main task are reset**.

Alternative task

The grinding in the corridor begins to subside little by little, but you prudently do not rush to leave the place that was once used as an office. Having carefully examined the videographer, clicking all the toggle switches and examining the map, you wait for the noise in the corridor to subside to zero.

Mechanically opening the lid of the breguet, you see that the watch is standing still. There is a feeling that you need to be surprised, but this place has taught you not to do it. You phlegmatically decide that since time stands still, it must either be spent usefully or killed. In the absence of anything better, you begin to study the cabinet in more detail and soon notice that the breguet's hands move with (or maybe after?) you. After making a few confusing movements around the office and closely following the second hand of the clock, you realize that it does not move by chance, but points to the same place in the office.

Inside you, everything becomes wobbly from recent memories of what was in the corridor, but you still go to the part of the wall of the office that the clock hands point to. Having carefully examined it, you notice that one of the wall tiles protrudes slightly more than the others. With a trembling hand, you press it and hear an old mechanism triggered, and an ingenious system of levers and counterweights opens a small hiding place.

You turn up the light of the gas-discharge lamp and see an old notebook lying in it. Carefully leafing through it, you realize that these are the drafts of the one who worked here on all these mechanisms that fill this damn tunnel.

Notes from the notebook

Two halves of a rod of length $2L$ and constant cross-sectional area S are made of different materials. The thermal conductivity of the material from which the first half of the rod is made is $\varkappa_1$, and the thermal conductivity of the second half is $\varkappa_2$. The temperatures at the ends of the rod are maintained equal to T_1 and T_2, respectively. The side surface of the rod is thermally insulated.

1. *(2 points)* Find the temperature and density of the heat flux in the middle of the rod.
2. *(1 point)* Answer the first item if $\varkappa_2 \to 0$.
3. *(1 point)* Answer the first item if $\varkappa_2 \to \infty$.

Part 2. Sphere

(2 points) A conducting sphere of radius R is placed in a uniform electric field with a strength of E. Find the surface charge density at an arbitrary point on the sphere.

Part 3. Effusion

(1 point) In a vessel with gas, the temperature T_0 is maintained. Outside it is a gas which pressure is P and temperature is T. What is the pressure of the gas inside the vessel if there is a small hole in the wall of the vessel? The gases are rarefied.

Part 4. Convection

(3 points) The space between two large horizontally oriented plates located at a distance l from each other is filled with air. The temperature of the lower plate is maintained equal to T_1, and the upper plate is equal to $T_2 < T_1$. Considering air as an ideal gas, determine at what temperature difference $T_1 - T_2$, convection occurs in the system. Heat exchange between adjacent layers of air during convection can be neglected. In the absence of convection, the temperature changes linearly with height. Consider the molar heat capacity of air at constant volume and its molar mass to be known.