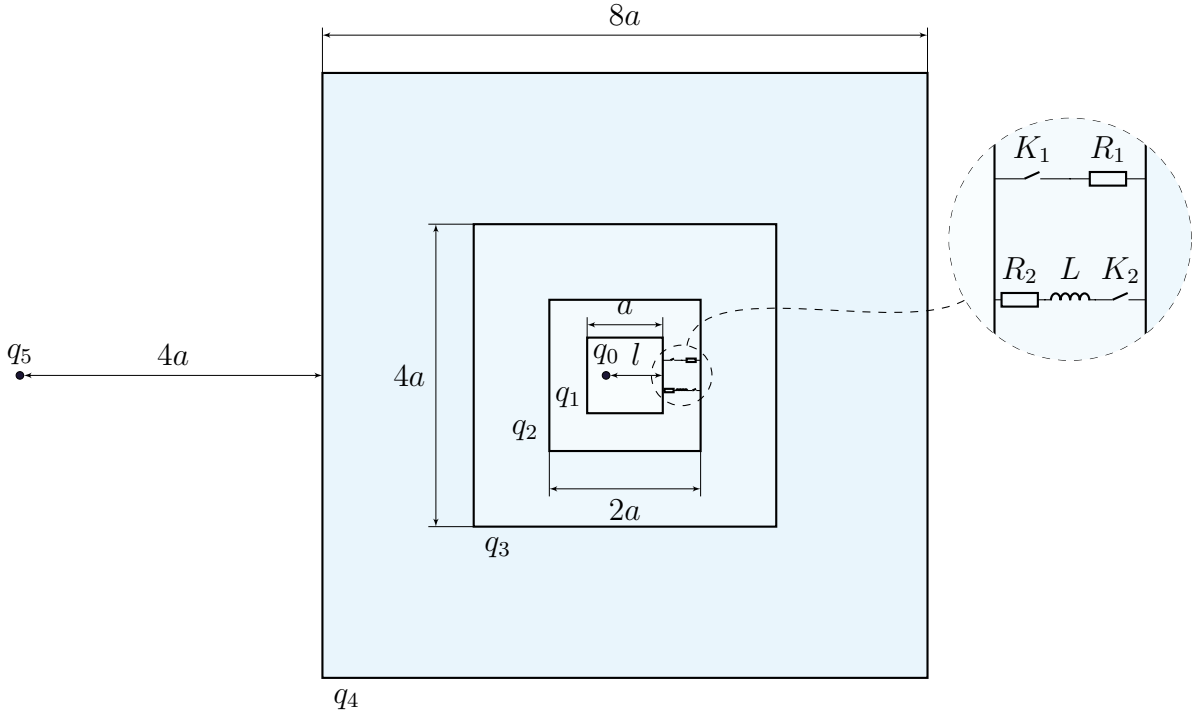
11.s04.e01

We've got some rough times ahead,
but it's going to be ok, because we're family.
Dominic Toretto, "F9"

Cubic Matryoshka

Thin-walled hollow conducting concentric Cubie, Cube, Cubess and Cuborg with sides a, $2a$, $4a$, $8a$ charged with $q_1 = q$, $q_2 = 4q$, $q_3 = 4q$ and $q_4 = 10q$ respectively. Inside Cubie on the axis passing through the centers of opposite faces, at a distance $l = 3a/4$ from the center of the Cubie's face there is a point charge $q_0 = q$. Outside Cuborg on the same axis at a distance $4a$ from he's face there is a point charge $q_5 = 10q$ (see fig.). Let the potential be zero at infinity. Then the potential of the Cuborg is φ_{out}, and Cubie's potential is φ_{in}.



1. *(3 points)* What is the current through the resistor R_1 immediately after closing the key K_1? The resistance R_1 is much greater than the resistance of the Cubes.
2. *(2 points)* How much charge will flow through the key K_1 after its closure?

Continued next page

3. *(3 points)* How much heat will be released during this process?
4. *(2 points)* Consider that we did not close the key K_1. What is the frequency of oscillations when the key K_2 is closed?

The inductance of the Cubes can be neglected. The resistance R_2 is much greater than the resistance of the Cubes, but it is small enough for the losses over the period to be much less than the energy of oscillations.

First hint — 24.04.2023 20:00 (Moscow time)
Second hint — 26.04.2023 12:00 (Moscow time)

Final of the first round — 28.04.2023 20:00 (Moscow time)