

I'm having a little bit of a problem with IPhO theory question 1 2004.

Relevant equations:

$$V = \frac{Q}{C}$$

$$C = \frac{A\epsilon_0}{d}$$

$$E = \frac{V}{d}$$

$$F_{el} = qE$$

$$v_2^2 - v_1^2 = 2ad$$

Part a is quite easy, keeping in mind that the lower plate is negatively charged:

$$F = \frac{1}{2} * -QE = -\frac{1}{2}VC * \frac{V}{d}$$

$$F = -\frac{\pi R^2 \epsilon_0 V^2}{2d^2}$$

b) can be calculated quite easily too, again keeping in mind the lower plate is negatively charged:

$$q = \chi V = -VC_1 = -\frac{\pi r^2 \epsilon_0}{d}$$

$$\chi = -\frac{\pi r^2 \epsilon_0}{d}$$

Then for c) the force on the small plate due to the electric field should be greater than the force due to the weight of the plate:

$$F_{el} \geq F_w$$

$$qE \geq mg$$

$$\chi V \frac{V}{d} \geq mg$$

$$V^2 \geq \frac{mgd}{\chi}$$

Giving for $V_{threshold}$

$$V \geq \sqrt{\frac{mgd}{\chi}}$$

But now I'm going wrong with d). Assuming that the steady state speed has been reached, right after the collision with the lower plate the small plate travels up with a speed v_s . It will be accelerated by the electric field and reaches the upper plate with a speed v_1 . The collision is inelastic, therefore right after the collision the plate travels down with a speed of $v_2 = \eta v_1$. Again the small plate is accelerated by the gravitational field and the electric field, and reaches the bottom plate with a speed v_3 . After collision with the bottom plate, as the steady state speed has been reached, it should return to $v_s = \eta v_3$

If the acceleration upwards is a_1 and the acceleration downwards is a_2 , they are different due to the direction of the gravitational field,

$$v_1^2 = v_s^2 + 2a_1d$$

$$v_2 = \eta v_1$$

$$v_3^2 = v_2^2 + 2a_2d = \eta^2 v_1^2 + 2a_2d$$

$$v_s^2 = \eta^2 v_3^2 = \eta^2(\eta^2 v_1^2 + 2a_2d) = \eta^4(v_s^2 + 2a_1d) + \eta^2(2a_2d)$$

Now there are terms η^4 in the equation for v_s . Therefore it's quite unlikely that this equation will lead to the answer provided by the solutions manual.