

8. CONNECTED CHARGES (8 points) — Jaan Kalda.

In the region $0 < x < L$, there is an electric field $\vec{E} = E_0 \hat{x}$, where $\hat{x}$ denotes the unit vector parallel to the x -axis. Two small balls, each of mass m and carrying charge q ($qE_0 > 0$) are connected with a weightless non-stretchable string of length l . Initially, at the moment of time $t = 0$, the string is taut, the velocity of the both balls is $\vec{v} = v_0 \hat{x}$, one of the balls, the ball A , is at $x = 0$ while the other ball, the ball B is at $x < 0$. The electric field created by the balls can be neglected, and it can be assumed that v_0 is very small (much smaller than $\sqrt{ELq/m}$).

i) (2 points) Consider the case when the string is parallel to the x -axis, and $l = L$. Sketch the dependence of the velocity of the both balls as a function of time. Will the balls collide? If yes then when?

ii) (2 points) Now, at $t = 0$, the string forms an angle of 45° with the x -axis, $l = 1.2291L$. By this string length, at the moment $t = T$ when the ball A reaches $x = L$, the string is parallel to the x -axis. Find T .

iii) (2 points) Under the assumptions of the previous task, what is the speed of the ball A at the moment $t = T$?

iv) (2 points) Now, at $t = 0$, the string forms a very small angle ϕ with the x -axis. Similarly to the previous two tasks, at the moment $t = T'$ when the ball A reaches $x = L$, the string is parallel to the x -axis. Find the string length l assuming that $l > L$. The answer to

this point should contain only L and numerical constants.