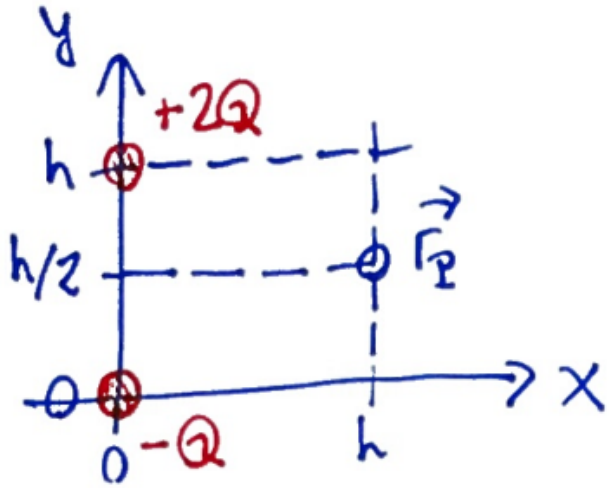
6. Consider two electric charges with values

$$\begin{aligned} q_1 &= -Q \\ q_2 &= +2Q \end{aligned}$$

distributed as in the following diagram:



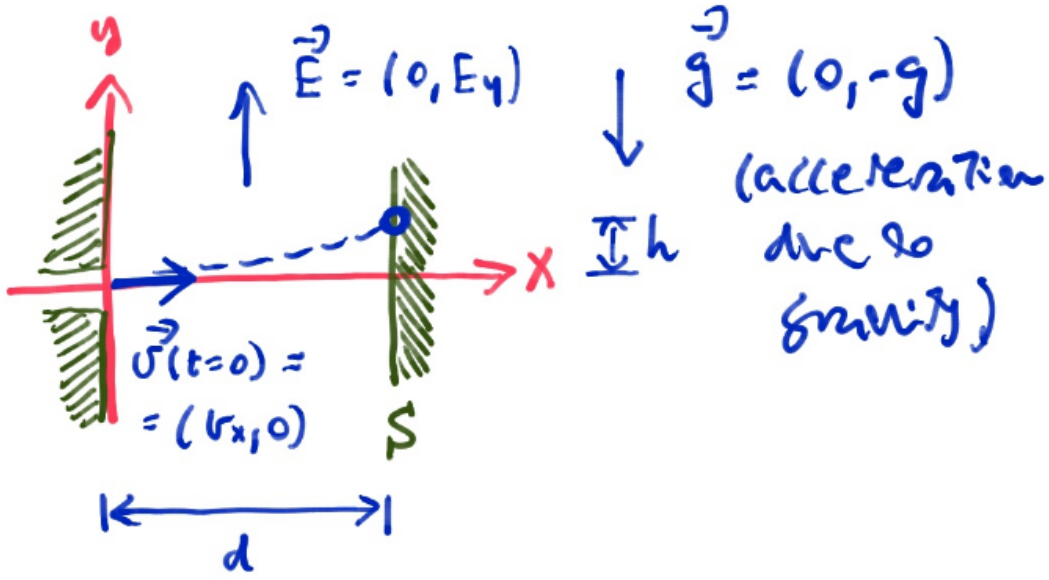
Assume that the charge Q and length h are known quantities.

(a) What is the field $\vec{E}\,(\vec{r}_P)$ at the point $\vec{r}_P = (h, h/2)$?

(b) Draw at $\vec{r}_P$ the three fields

$$\begin{aligned} \vec{E}\,(\vec{r}_P) &\quad \text{(total field)} \\ \vec{E}_1\,(\vec{r}_P) &\quad \text{(contribution from } q_1\text{)} \\ \vec{E}_2\,(\vec{r}_P) &\quad \text{(contribution from } q_2\text{)} \end{aligned}$$

7. A charged particle comes out of a nozzle at $(x, y) = (0, 0)$ with initial velocity $\vec{v}(t = 0) = v_x \hat{i}$. After travelling a distance d it hits a screen a distance d from the nozzle. The particle is subject to a constant, uniform, vertical electric field $\vec{E} = (0, E_y)$ and also suffers a downard acceleration $\vec{g} = (0, -g)$ due to gravity:

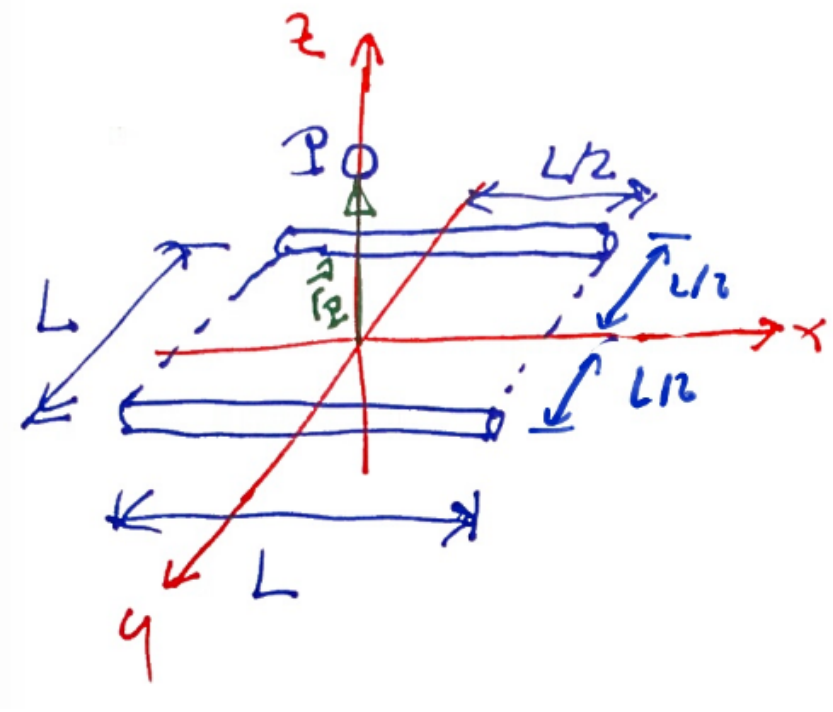


(a) Find the height h at which the particle hits the screen S as function of v_x, E_y, g, and d.

(b) What value of E_y is necessary to ensure the particle hits the screen at $h = 0$?

Hint: *in the latter case, the total force on the particle must be* $\vec{F} = 0$.

8. Consider two identical rods, each with the same, uniform charge density per unit length, λ. If the rods are arranged so they are parallel to each other and separated by a fixed distance L, as in the figure, what is the field $\vec{E}\,(\vec{r}_P)$ at a point P which is on the z axis at a height z above the $x-y$ plane?

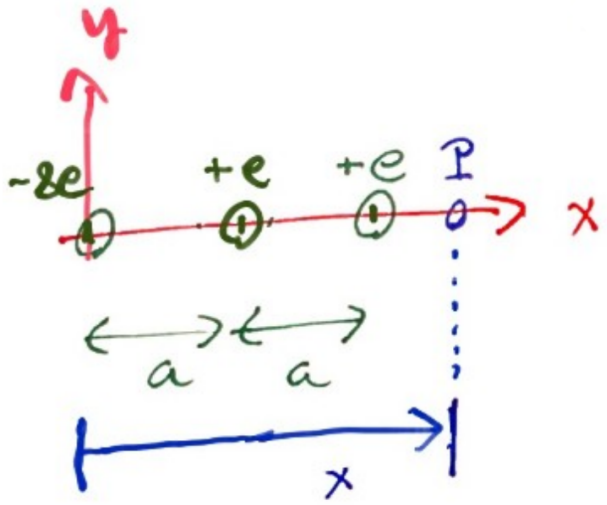


Give your answer in terms of the parameters λ, L and z.

Hint: *a side-view drawing may drawing may help.*

Hint: *Use our results for a single rod + the superposition principle:* $\vec{E} = \vec{E}_1 + \vec{E}_2$. *Bear in mind that the result in the lectures was written in a different coordinate frame.*

9. Consider an ionised molecule formed by three ions arranged as shown and with the charges of the ions as given in the picture:



(a) Calculate the electrostatic potential $V(x)$ at a point P located on the longitudinal axis of the molecule, as shown. Use the convention $V(x \to \infty) = 0$. Give your results as a function of x, the bond length a, and the electronic charge e. Draw a $V(x)$ vs x plot.

(b) What is the contribution to the potential energy of an electron due to the ions when the electron is at the mid-point between the negative ion and one of the positive ions, $x_P = a/2$?

10. For the ionised molecule of Problem 9, calculate the force on an electron that is at an arbitrary position on the x-axis,

$$\vec{r} = x\hat{i} = (x, 0)\,.$$

Hint: *By symmetry,* $\vec{F} = F_x\hat{i} = (F_x, 0)$. *Now use* $\vec{F} = -e\vec{E}$ *and* $\vec{E} = -\nabla V$.