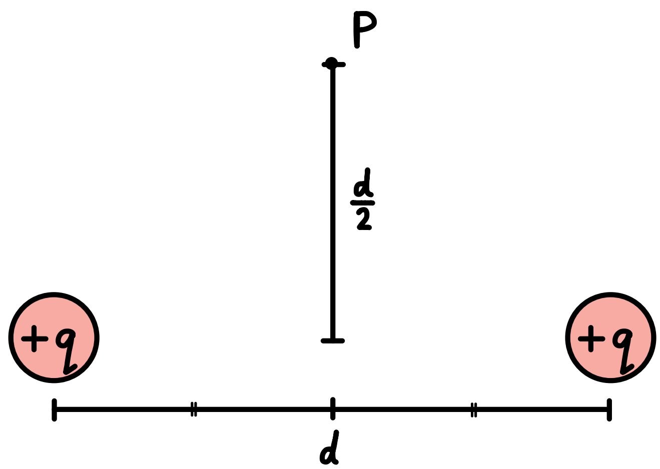
Sketch the electric field lines associated with two point charges $+q$ and $-2q$, separated by distance d.

Two point charges of charge +*q* are separated by a distance *d*.

a) What is the electric field at a point P in terms of *q* and *d*?

b) Determine the location of a third charge of +*q* such that the electric field at point *P* due to the three charges is zero.



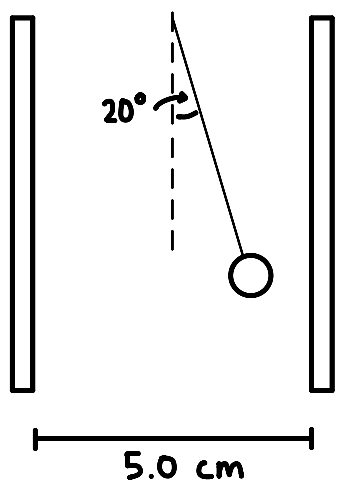
In radioactive “α decay”, an unstable nucleus emits a helium-atom nucleus, which is an α particle. The α particle is made up of two protons and two neutrons, thus having a mass m=4 amu and charge q=2e.

When a uranium nucleus (with 92 protons) decays into thorium (which has 90 protons), and an α particle, we can detect the α particle with a Geiger counter: U → Th + α
Assume the α particle is initially at rest at the surface of the thorium nucleus, which is 15 fm in diameter. What is the speed of the alpha particle when we detect it in the laboratory using a Geiger counter? You can neglect the recoil of the thorium nucleus, it’s tiny (ie. assume the thorium nucleus remains at rest).

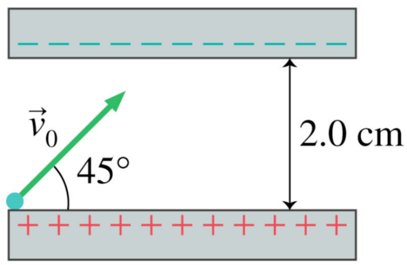
Two oppositely charged parallel plates are separated by a distance of 5.0 cm. A 50 μg sphere of charge -500 nC is suspended by a light thread between parallel plates as shown in the diagram below. The thread makes an angle of 20° with the vertical.

a) Determine the potential difference between the plates.

b) Indicate which plate is positive and which is negative.



Two oppositely charged parallel plates are 2.0 cm apart with a 1.0×10^4 N/C electric field strength between them. An electron is launched at an angle of 45° from the positive plate, as shown. What is the maximum initial speed, *v*_0, the electron can have without hitting the negative plate?



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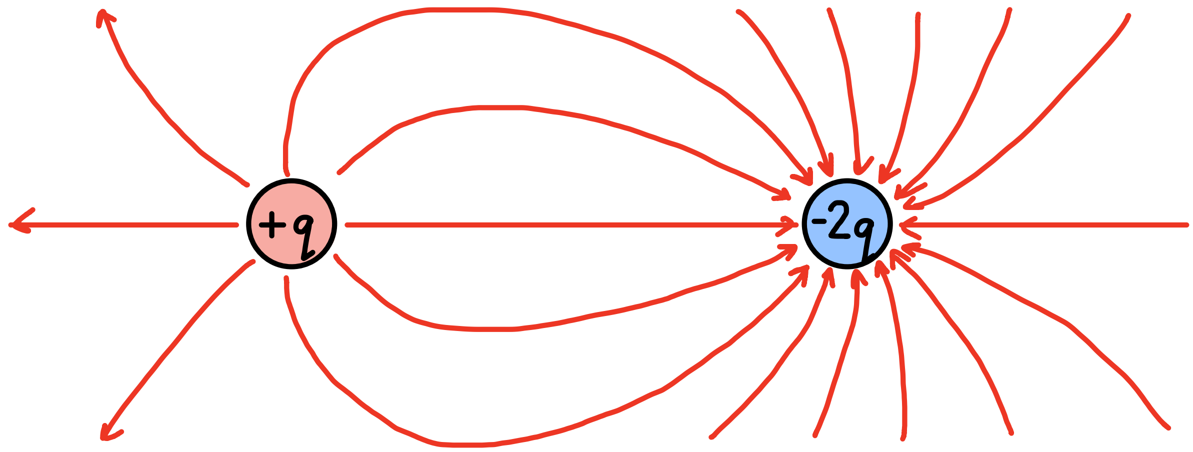
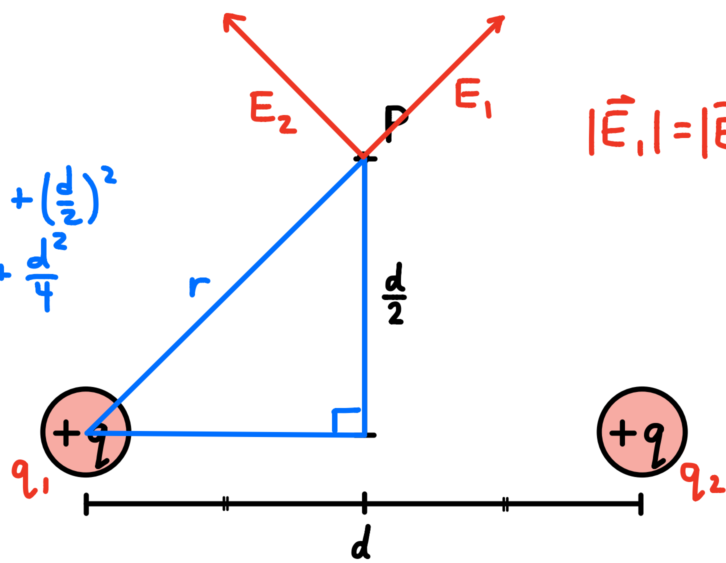


Two point charges of charge $+q$ are separated by a distance d.

a) What is the electric field at a point P in terms of q and d?

b) Determine the location of a third charge of $+q$ such that the electric field at point P due to the three charges is zero.

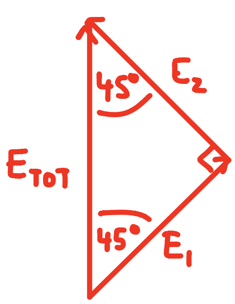
a)



$$r^2 = \left(\frac{d}{2}\right)^2 + \left(\frac{d}{2}\right)^2$$
$$= \frac{d^2}{4} + \frac{d^2}{4}$$
$$= \frac{d^2}{2}$$

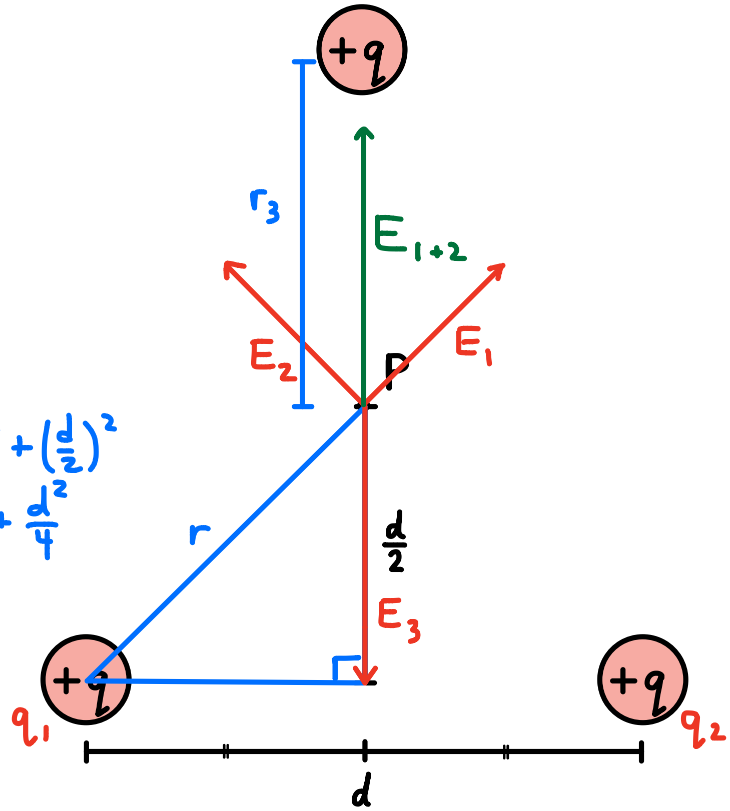
$$|\vec{E}_1| = |\vec{E}_2| = k\frac{q}{r^2} = 2k\frac{q}{d^2}$$

$$\vec{E}_{TOT} = \vec{E}_1 + \vec{E}_2$$



$$E_{TOT}^2 = E_1^2 + E_2^2$$
$$= \left(2k\frac{q}{d^2}\right)^2 + \left(2k\frac{q}{d^2}\right)^2$$
$$= 8\left(k\frac{q}{d^2}\right)^2$$
$$E_{TOT} = \boxed{2\sqrt{2}\, k\frac{q}{d^2} \quad \text{UP}}$$
$$= 2.83\, k\frac{q}{d^2} \quad \text{UP}$$

b)



$$r^2 = \left(\frac{d}{2}\right)^2 + \left(\frac{d}{2}\right)^2$$
$$= \frac{d^2}{4} + \frac{d^2}{4}$$
$$= \frac{d^2}{2}$$

$$\vec{E}_{TOT} = 0$$

$$\vec{E}_1 + \vec{E}_2 + \vec{E}_3 = 0$$

$$\vec{E}_{1+2} + \vec{E}_3 = 0$$

$$|\vec{E}_{1+2}| = |\vec{E}_3|$$

$$2\sqrt{2}\, \cancel{k} \frac{\cancel{q}}{d^2} = \cancel{k} \frac{\cancel{q}}{r_3^2}$$

$$\frac{2\sqrt{2}}{d^2} = \frac{1}{r_3^2}$$

$$r_3 = \boxed{\frac{d}{\sqrt[4]{8}} \text{ ABOVE P}}$$

$$= 0.595\, d \text{ ABOVE P}$$

In radioactive “α decay”, an unstable nucleus emits a helium-atom nucleus, which is an α particle. The α particle is made up of two protons and two neutrons, thus having a mass *m*=4 amu and charge *q*=2*e*.

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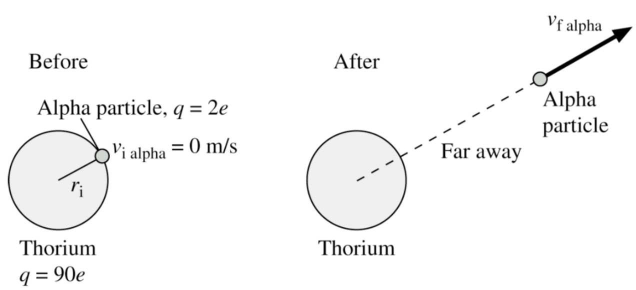

$$E_i = E_f$$

$$E_{k_i} + E_{p_i} = E_{k_f} + E_{p_f}$$

($E_{k_i} = 0$; $r = \infty$ so $E_{p_f} = 0$)

$$k\frac{Qq}{r_i} = \frac{1}{2} m v_f^2$$

$$v_f = \sqrt{2k\frac{Qq}{m r_i}}$$

$$= \sqrt{2(9.00\times10^{9})\frac{[(90)(1.60\times10^{-19})][(2)(1.60\times10^{-19})]}{[(4)(1.67\times10^{-27})(7.5\times10^{-15})]}}$$

$$= \boxed{4.07\times10^{7}\ \frac{m}{s}}$$

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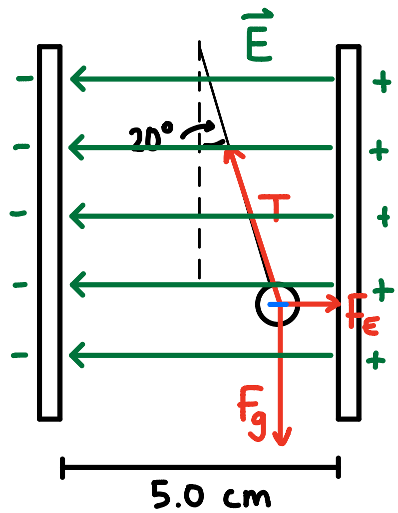
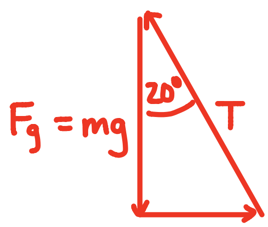
a) Determine the potential difference between the plates.

b) Indicate which plate is positive and which is negative.



$$\vec{F}_{NET} = 0$$

$$\vec{F}_g + \vec{F}_E + \vec{T} = 0$$



$$F_E = qE = q\frac{\Delta V}{d}$$

$$F_E = F_g \tan 20°$$

$$q\frac{\Delta V}{d} = mg\tan 20°$$

$$\Delta V = \frac{mgd}{q}\tan 20°$$

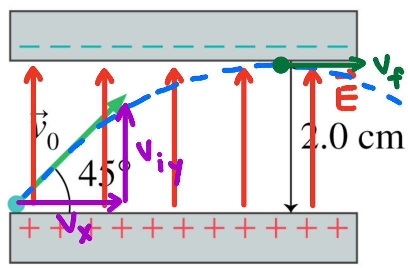
$$= \frac{(50\times10^{-9})(9.8)(0.050)}{500\times10^{-9}}\tan 20°$$

$$= \boxed{0.0178\ V}$$

b) RIGHT PLATE IS POSITIVE

- F_E ON NEGATIVE CHARGE IS TO THE RIGHT.
- E MUST BE TO THE LEFT
- RIGHT PLATE MUST BE AT HIGHER POTENTIAL

Two oppositely charged parallel plates are 2.0 cm apart with a 1.0×10^4 N/C electric field strength between them. An electron is launched at an angle of 45° from the positive plate, as shown. What is the maximum initial speed, *v*_0, the electron can have without hitting the negative plate?



- E-FIELD IS UNIFORM BETWEEN PARALLEL PLATES.
- CONSTANT DOWNWARDS ELECTRIC FORCE ON ELECTRON

→ PROJECTILE MOTION

$v_{iy} = v_0 \sin 45°$

$v_{fy} = 0$

$a_y = -\frac{F_e}{m} = -\frac{qE}{m}$

$d_y = 0.020\ m$

$$v_{fy}^2 = v_{iy}^2 + 2a_y d_y \quad (v_{fy} = 0)$$

$$v_{iy} = \sqrt{-2a_y d_y}$$

$$v_0 \sin 45° = \sqrt{2\left(\frac{qE}{m}\right) d_y}$$

$$\frac{v_0}{\sqrt{2}} = \sqrt{\frac{2qEd_y}{m}}$$

$$v_0 = 2\sqrt{\frac{qEd_y}{m}}$$

$$= 2\sqrt{\frac{(1.60\times10^{-19})(1\times10^{4})(0.020)}{9.11\times10^{-31}}}$$

$$= \boxed{1.19\times10^{7}\ \frac{m}{s}}$$