Electric Charge

positive (proton)

(electron) negative

(+) (+) → repel

(−) (−) → repel

(+) (−) → attract

Charge unit = columb (C)

$e = -1.6 \times 10^{-19}$ C

$p = +1.6 \times 10^{-19}$ C

$m_p > m_e$

neutron ⇒ no charge (neutral) ⇒ $m_n = m_p$

charge is quantized ⇒ $Q = N e$

↳ N is an integer

charge is conserved ⇒ cannot be destroyed or created (isolated system)

conductors
↓
copper
↓
free electrons

insulators
↓
rubber, glass
↓
no free electrons

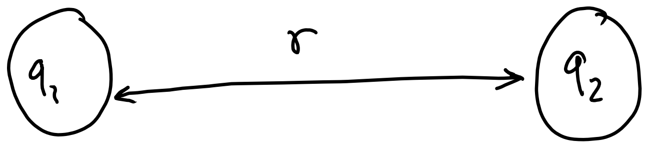
semiconductors
↓
silicon, Ge
doping

Electrostatic Force (columb's Law)

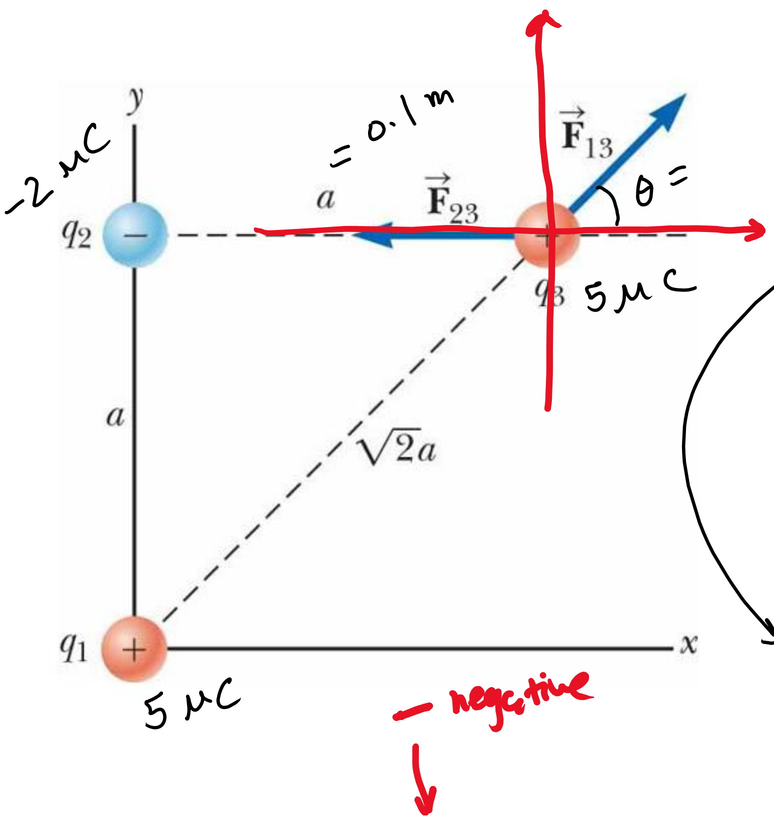
$$F_e = \frac{K_e \, q_1 \, q_2}{r^2}$$

$K_e = 8.89 \times 10^9$

columb's constant



$$|\vec{F}_{12}| = |\vec{F}_{21}|$$



$$\mu C = 10^{-6}$$

$$F_{13} = \frac{k_e \, q_1 \, q_3}{(\sqrt{2}\, a)^2}$$

$$F_{23} = \frac{k_e \, q_2 \, q_3}{a^2}$$

$$F_{13x} = F_{13} \cos \theta$$

$$F_{13y} = F_{13} \sin \theta$$

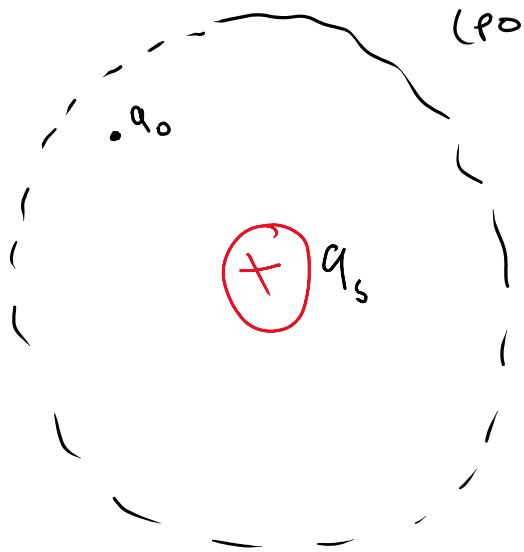
$$F = (\vec{F}_{13}x + \vec{F}_{23})\vec{i} + F_{13y}\vec{j}$$

Electric Field:

q_s = source charge

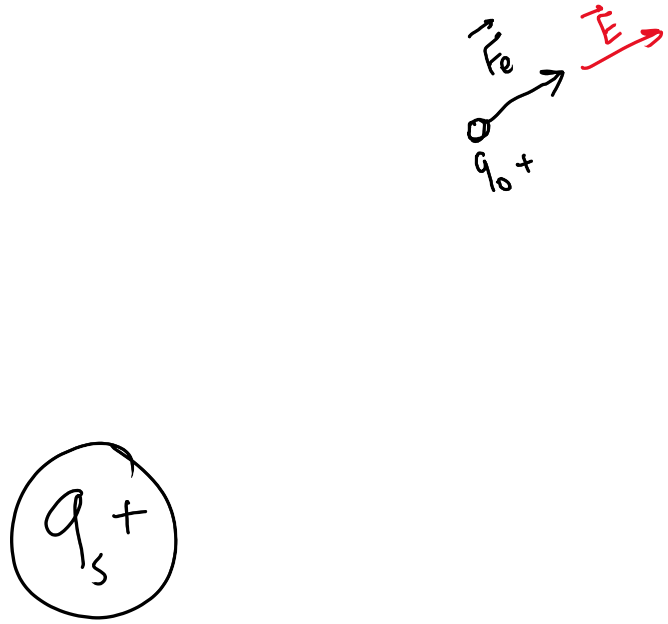
q_0 = test charge (positive)

$$\vec{E} = \frac{\vec{F}_e}{q_0}$$



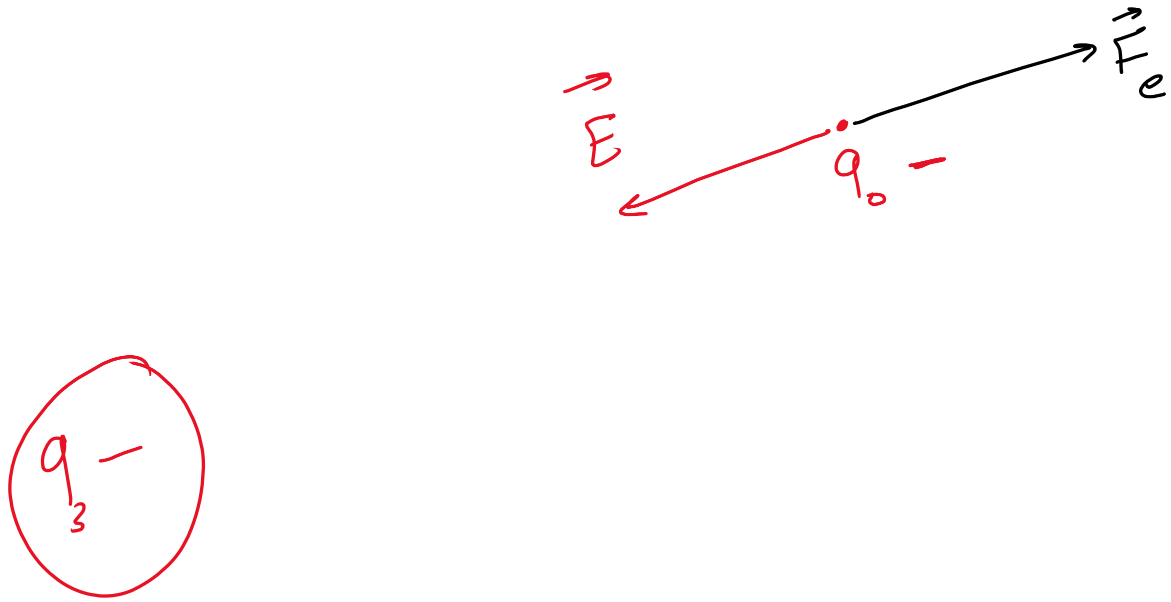
test charge is positive ⇒ $\vec{F}_e$ & $\vec{E}$ have same direction

" " " negative ⇒ $\vec{F}_e$ & $\vec{E}$ opposite directions



$\vec{F_e}$
$\vec{E}$
q_0 +
q_s +

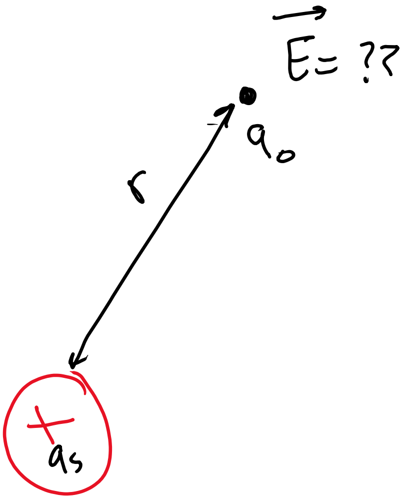
$\vec{F_e}$
q_0 +
$\vec{E}$
q_s −



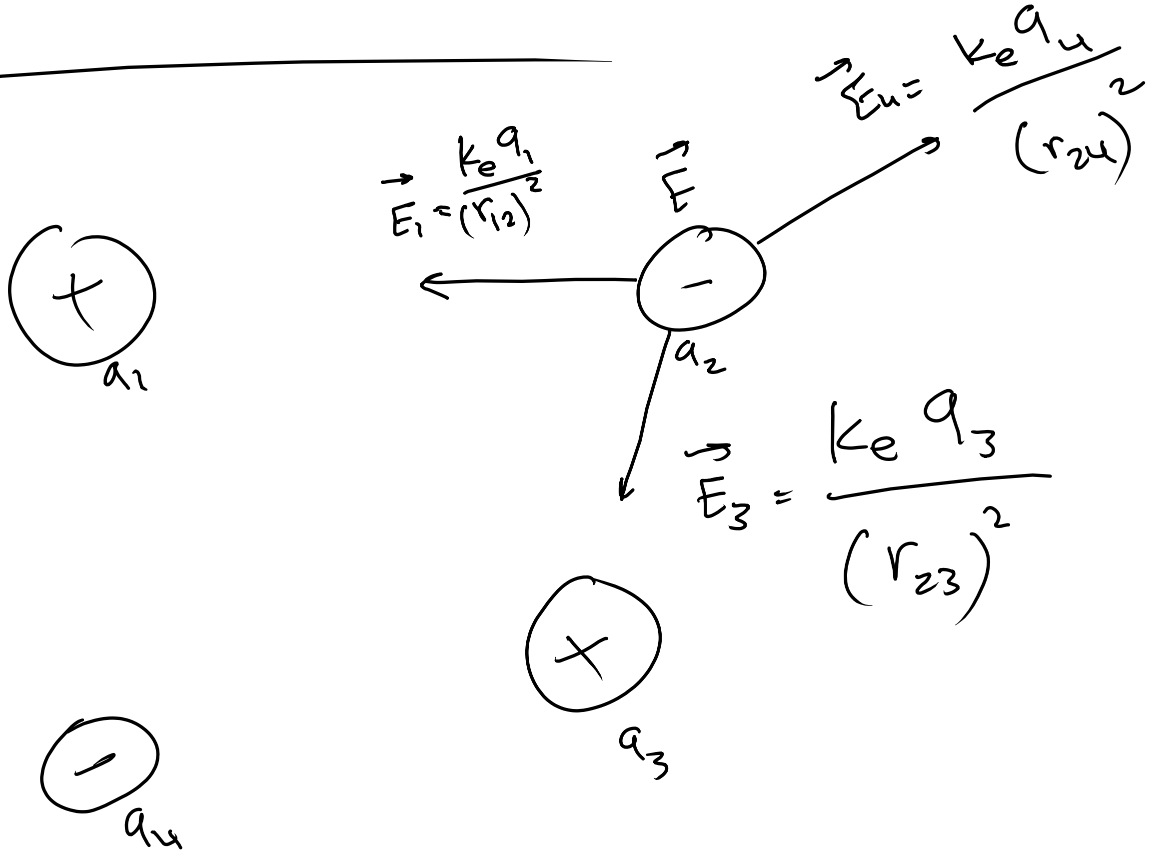
$\vec{F_e}$
$\vec{E}$
q_0 −
q_s −

$$\vec{E} = \frac{\vec{F}_e}{q_0} = \frac{k_e q_s q_0}{r^2 q_0}$$

$$\boxed{= \frac{k_e q_s}{r^2}}$$



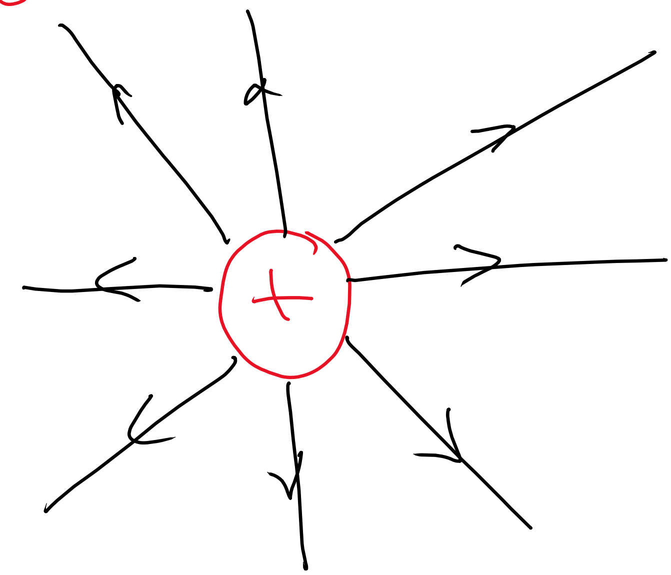
$$\frac{\vec{F}_{12} + \vec{F}_{32} + \vec{F}_{42}}{q_2}$$

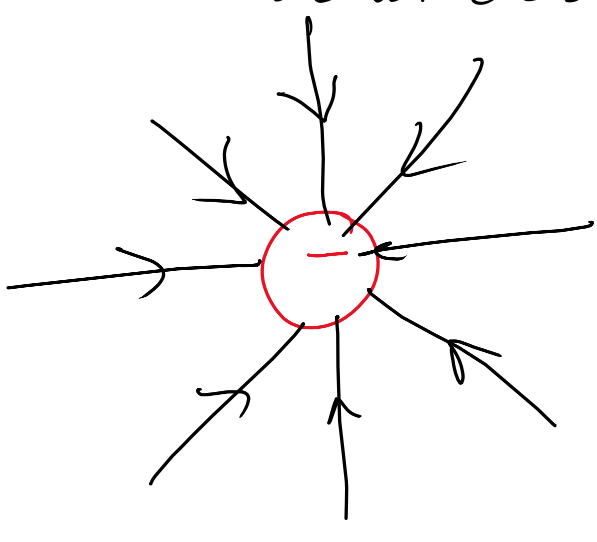


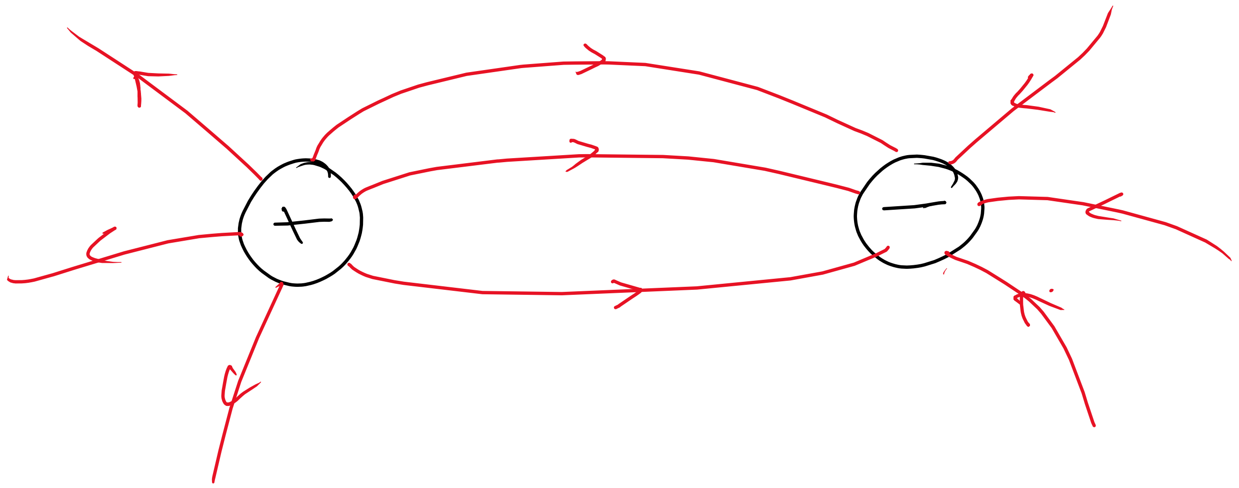
Electric Field lines

↑ Q ⟹ more lines

do not cross







$$\vec{E} = \frac{\vec{F_e}}{q_0} \Rightarrow \vec{F_e} = \vec{E}\, q_0 = m\, \vec{a}$$

$$\Rightarrow \vec{a} = \frac{\vec{E}\, q_0}{m}$$

$\vec{E}$ is uniform $\Rightarrow$ $\vec{a}$ is constant

Same magnitude & direction at all points

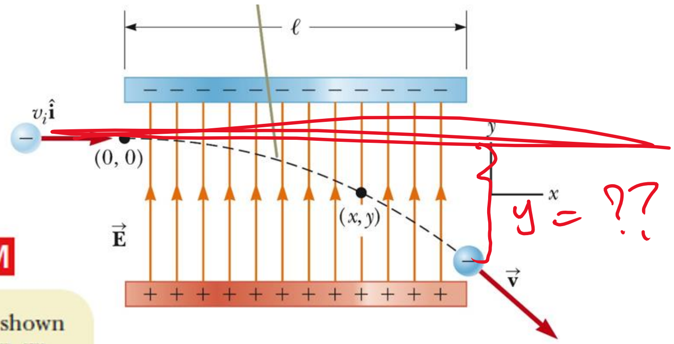
particle under constant acceleration

$$x_f = x_0 + v_0 t + \frac{1}{2} a t^2$$

acceleration.

- It is negative, so the acceleration is opposite the direction of the field.

Its motion is parabolic while between the plates.



0

$y = ??$

$m_e = 9.11 \times 10^{-31}$ Kg

Example 23.11 An Accelerated Electron **AM**

An electron enters the region of a uniform electric field as shown in Figure 23.24, with $v_i = 3.00 \times 10^6$ m/s and $E = 200$ N/C. The horizontal length of the plates is $\ell = 0.100$ m.

(A) Find the acceleration of the electron while it is in the electric field.

charge is negative ⇒ goes opposite the electric field

" " positive ⇒ same direction as $\vec{E}$

$$a = \frac{200 \times 1.6 \times 10^{-19}}{9.11 \times 10^{-31}} = - \square \, \hat{j}$$

(B) Assuming the electron enters the field at time $t = 0$, find the time at which it leaves the field.

$$x_f = x_i + v_{0x} t + \cancel{\tfrac{1}{2} a_x t^2} \quad 0$$

$$\boxed{y_f = y_i + v_{0y} t + \tfrac{1}{2} a_y t^2}$$

$$0.1 = 0 + (3 \times 10^6) t + 0$$

(C) Assuming the vertical position of the electron as it enters the field is $y_i = 0$, what is its vertical position when it leaves the field?

$$y_f = 0 + 0 + \frac{1}{2} a_y t^2$$

$\Downarrow$ (a) $\qquad \Downarrow$ (b)