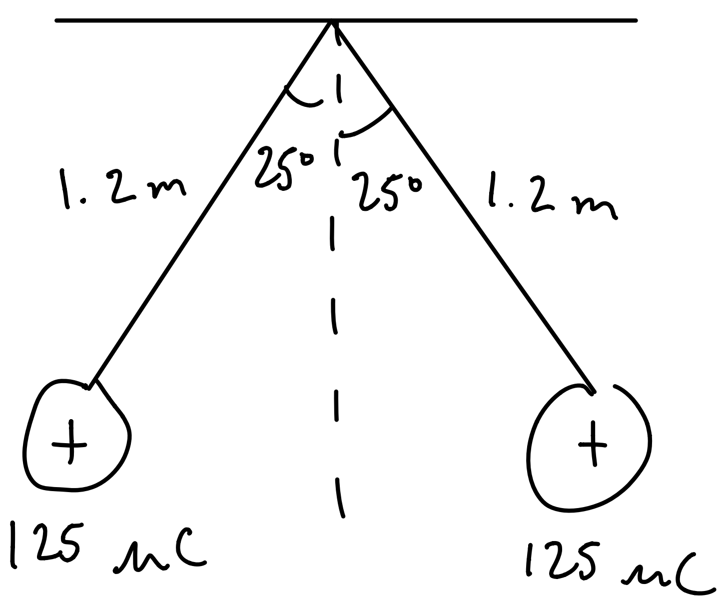
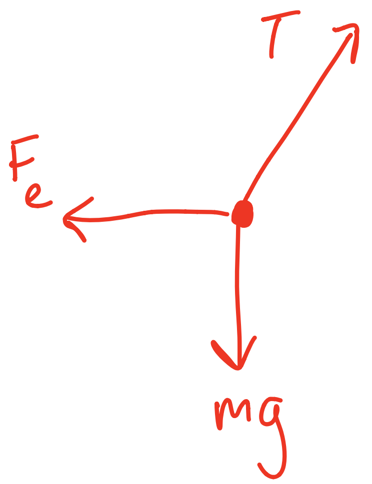
① Two spheres with a mass "m" on threads of length 1.2 m repel each other after being equally charged, as shown below. What is the mass "m"?





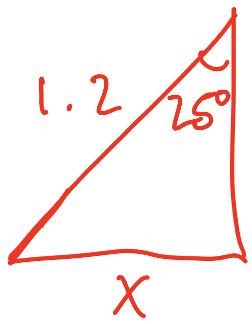
$$T\sin\theta = F_e \Rightarrow T = \frac{F_e}{\sin\theta}$$

$$T\cos\theta = mg \Rightarrow T = \frac{mg}{\cos\theta}$$

$$\frac{F_e}{\sin\theta} = \frac{mg}{\cos\theta}$$

$$F_e = k\frac{(q_1)(q_2)}{r^2}$$

$$m = \frac{F_e\cos\theta}{g\sin\theta}$$



$$\sin 25^\circ = \frac{x}{1.2}$$

$$1.2 \sin 25^\circ = x$$

$$x = .507 \text{ m}$$

$$\Rightarrow r = 2x = 1.01 \text{m}$$

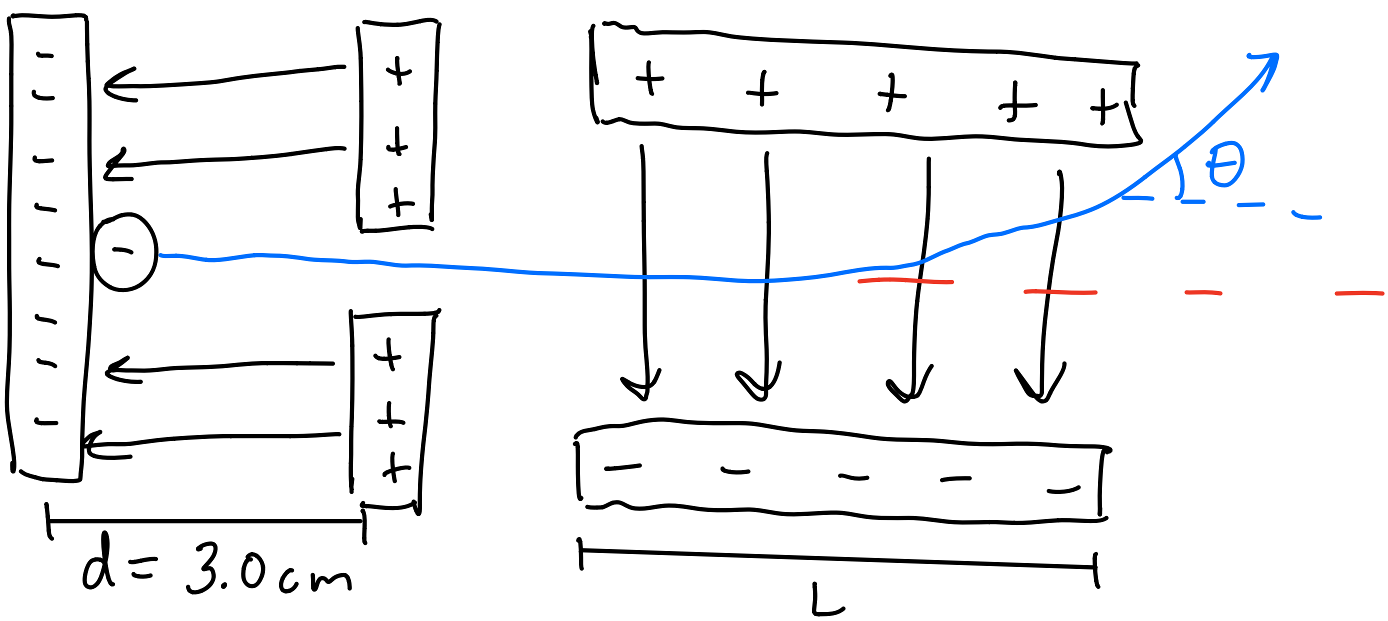
$$m = \frac{\frac{kq^2}{r^2}\cos\theta}{g \sin\theta}$$

$$m = \frac{kq^2 \cos\theta}{r^2 g \sin\theta}$$

$$m = \frac{(8.99 \times 10^9)(1.25 \times 10^{-4})^2 (\cos 25^\circ)}{(1.01)^2 (9.8)(\sin 25^\circ)}$$

$$\boxed{m = 30.1 \text{ kg}}$$

② An electron is released from rest from the far left. The final velocity of the electron is 4.0×10^{7} m/s at an angle $\theta = 18°$. The magnitude of the electric fields are the same between the two plates. ($q_e = 1.6 \times 10^{-19}$ C)



a) What is the magnitude of the electric field, $\vec{E}$?

$$F = ma = Eq$$

$$E = \frac{ma}{q}$$

$$E = \frac{m(v'\cos\theta)^2}{2dq}$$

$$E = \frac{(9.11\times10^{-31})(4\times10^{7}\cos 18)^2}{2(.03)(1.6\times10^{-19})}$$

$$E = 1.37\times10^{5}\ \frac{N}{C}$$

$$d = \frac{1}{2}at^2$$

$$\Rightarrow t = \sqrt{\frac{2d}{a}}$$

$$a = \frac{\Delta v}{\Delta t} = \frac{v'\cos\theta}{\sqrt{\frac{2d}{a}}}$$

$$\left(a\sqrt{\frac{2d}{a}}\right)^2 = (v'\cos\theta)^2$$

$$a^{\cancel{2}}\frac{2d}{\cancel{a}} = (v'\cos\theta)^2$$

$$2da = (v'\cos\theta)^2$$

$$a = \frac{(v'\cos\theta)^2}{2d}$$

b) What is the length, L?

$$v = \frac{\Delta L}{\Delta t}$$

$$\Rightarrow L = v'_x t$$

$$F = ma = Eq$$

$$a_y = \frac{Eq}{m}$$

$$v'_y = a_y t$$

$$t = \frac{v'_y}{a_y}$$

$$t = \frac{m v' \sin\theta}{Eq}$$

$$L = v'\cos\theta\left(\frac{m v' \sin\theta}{Eq}\right)$$

$$L = \frac{v'^2 m \sin\theta \cos\theta}{Eq}$$

$$L = \frac{(4.0\times10^7)^2(9.11\times10^{-31})(\sin 18^\circ)(\cos 18^\circ)}{(1.37\times10^5)(1.6\times10^{-19})}$$

$$L = 1.95 \text{ cm}$$

(3) An infinite nonconducting sheet has a surface charge density $\frac{Q}{A} = 5.8\ pC/m^2$. How much work is done by the electric field due to the sheet if a proton is moved from the sheet to a point P at a distance $d = 3.56$ cm from the sheet?

$$W = Fd = Eqd = \frac{Q}{2\varepsilon_0 A} qd$$

$$W = \frac{Q}{A} \cdot \frac{qd}{2\varepsilon_0}$$

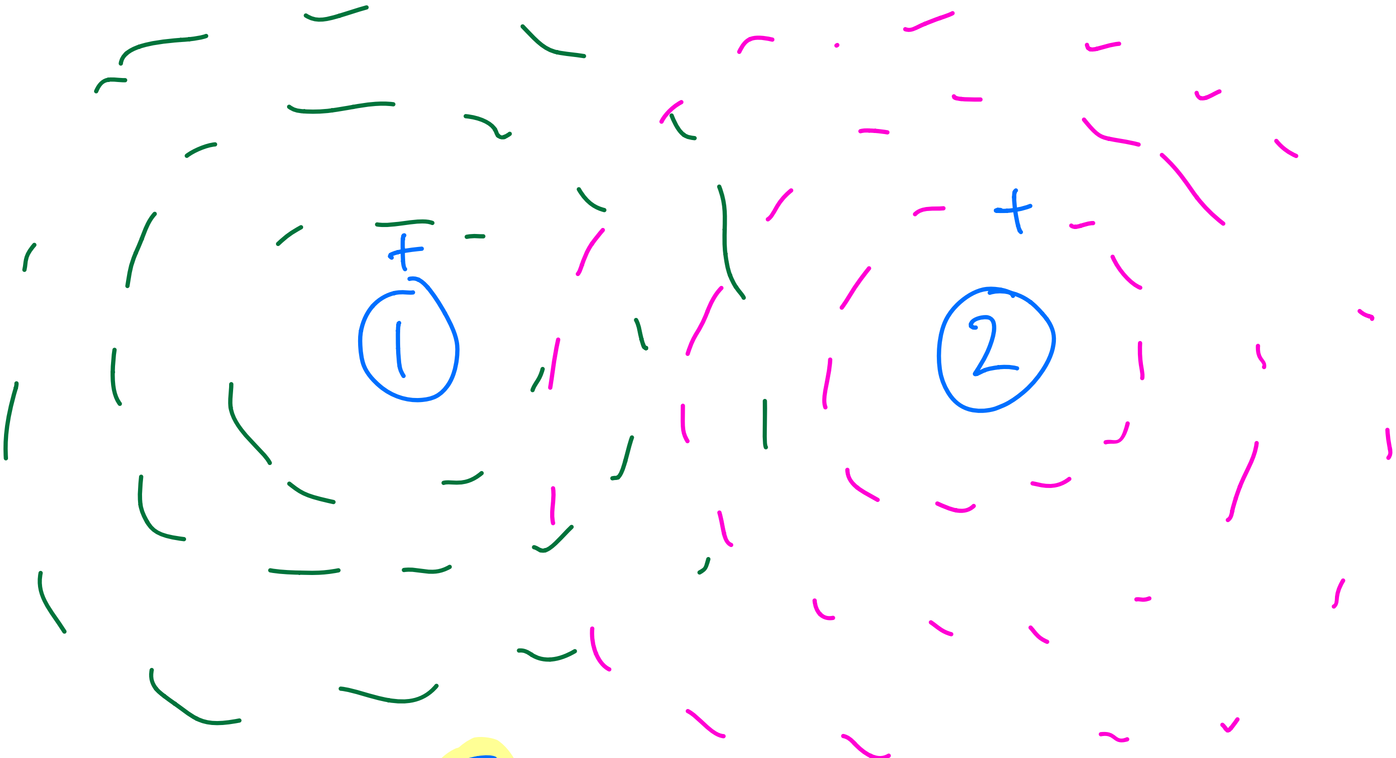
$$W = (5.8\times10^{-12}) \frac{(1.6\times10^{-19})(0.0356)}{(2)(8.85\times10^{-12})}$$

$$\boxed{W = 1.87 \times 10^{-21}\ J}$$

$$F_g = G\frac{m_1 m_2}{r^2} \qquad F_e = k\frac{|q_1||q_2|}{r^2}$$

$$F_e = q_2 \cdot k\frac{q_1}{r^2}$$

$$\therefore \quad E = k\frac{q_1}{r^2}$$



$$F_e = E q_2$$