Questions:

1. Two point charges, $-2.0\times10^{-5}C$ and $4.0\times10^{-5}C$ respectively, are separated by 10cm find
   a) The electric potential energy stored in the two charges
   b) The electric force between the two charges.

Given	RTF	Forumula
$q_1=-2.0\times10^{-5}C$ $q_2=+4.0\times10^{-5}C$ $d=0.10\,m$	a) E_e b) F_e	$E_e=\frac{kq_1q_2}{d}$, $F_e=\frac{kq_1q_2}{d^2}$

Solution

a)	b)
$E_e=\frac{kq_1q_2}{d}$ $E_e=\frac{(9.09\times10^9)(-2.0\times10^{-5})(+4.0\times10^{-5})}{0.10}$ $E_e=-72.72J$	$F_e=\frac{kq_1q_2}{d^2}$ $F_e=\frac{(9.09\times10^9)(-2.0\times10^{-5})(+4.0\times10^{-5})}{(0.10)^2}$ $F_e=-727.2N$ $\vec{F}_e=727.2N\,[attraction]$

2. Find the voltage and the electric field created by a $4.0\times10^{-5}C$ from a distance of
   a) 2.0m
   b) 4.0m

Given	RTF	Formula	
$Q_s=+4.0\times10^{-5}C$ Note: Q_s mean source charge where q_t is our test charge. The source charge is always MUCH larger than the test charge hence the upper and lower case notation. a) $d=2.0\,m$ b) $d=4.0\,m$	V and ε	$E_e=\frac{kQ_sq_t}{d}$ $\frac{E_e}{q_t}=\frac{kQ_s}{d}$ $V=\frac{E_e}{q_t}=\frac{kQ_s}{d}$	$F_e=\frac{kQ_sq_t}{d^2}$ $\frac{F_e}{q_t}=\frac{kQ_s}{d^2}$ $\varepsilon=\frac{F_e}{q_t}=\frac{kQ_s}{d^2}$

Solution

a) Voltage	Electric Field
$V=\frac{kQ_s}{d}$ $V=\frac{(9.09\times10^9)(+4.0\times10^{-5})}{(2.0)}$ $V=181800V$	$\varepsilon=\frac{kQ_s}{d^2}$ $\varepsilon=\frac{(9.09\times10^9)(+4.0\times10^{-5})}{(2.0)^2}$ $\varepsilon=90900N/C$

b) <u>Voltage</u>	<u>Electric Field</u>
$V = \frac{kQ_s}{d}$ $V = \frac{(9.09\times10^9)(+4.0\times10^{-5})}{(4.0)}$ $V = 90900V$	$\varepsilon = \frac{kQ_s}{d^2}$ $\varepsilon = \frac{(9.09\times10^9)(+4.0\times10^{-5})}{(4.0)^2}$ $\varepsilon = 22725N/C$

3. Two charged parallel plates are separated by a distance of 2.0cm. The voltage between the two plates is 500V. Find
   a) The electric field strength between the two plates
   b) Assuming the plates are no longer attached to a power supply, find the electric field strength between the plates if the distance is doubled.
   c) Assuming the plates are no longer attached to a power supply, find the voltage between the plates if the distance is doubled.

Given	RTF	Formula
$V = 500V$ a) $d = 0.020m$ b) $d = 0.040m$	a) ε b) ε if d is doubled and plates are decoupled c) ε if d is doubled and the plates are still attached	$\vec{\varepsilon} = -\frac{\Delta V}{\vec{d}}$ or $\lvert\vec{\varepsilon}\rvert = \frac{\Delta V}{d}$

Solution

a)

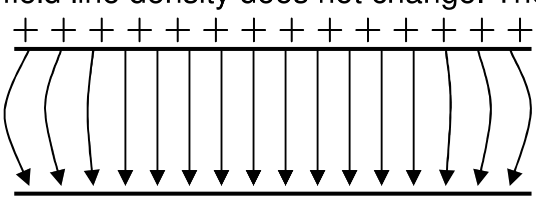
$$|\vec{\varepsilon}| = \frac{\Delta V}{d}$$

$$\varepsilon = \frac{500}{0.02}$$

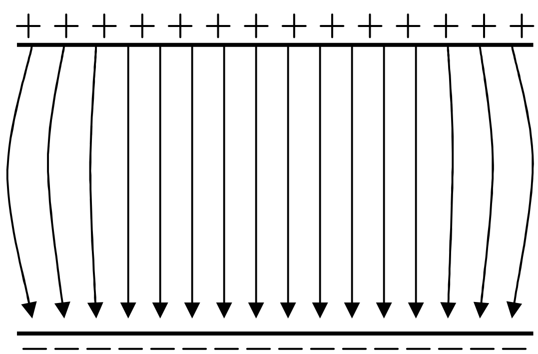
$$\varepsilon = 25000N/C$$

b)

Since the plates are decoupled and the field lines remain parallel, the electric field line density does not change. There fore $\therefore \varepsilon = 25000N/C$



Since the charge distribution doesn't change when the plates are decoupled from the power supply the field strength does not change but the voltage does. In this case V doubles as well. (part c))



c)

$$|\vec{\varepsilon}| = \frac{\Delta V}{d}$$

$$|\vec{\varepsilon}| d = \Delta V$$

$$\Delta V = (25000)(0.04)$$

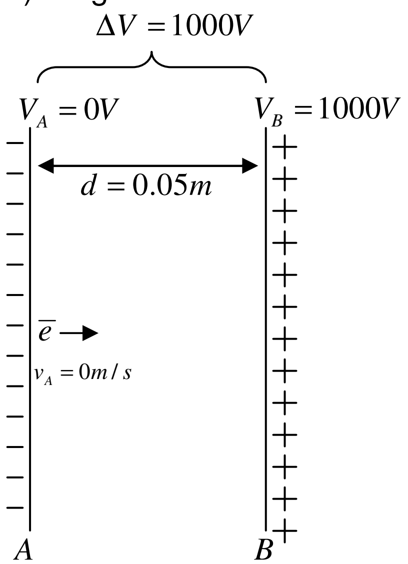
$$\Delta V = 1000V$$

4. Two parallel plates are attached to a 1000V power supply. If the plates are separated by a distance of 5.0cm, find
   a) the speed at which and electron will arrive at the positive plate ($m_e = 9.1\times10^{-31}kg$)
   b) the speed at which a proton would arrive at the negative plate ($m_p = 1.67\times10^{-27}kg$)
   c) calculate a) and b) if the distance between the two plates is doubled.

Given	RTF	Formula
$\Delta V = 1000V$ $d = 0.050m$ $m_e = 9.1\times10^{-31}kg$ $q_e = -1.6\times10^{-19}C$ $q_p = +1.6\times10^{-19}C$ $m_p = 1.67\times10^{-27}kg$	a) v_e b) v_p c) v_e and v_p if d is doubled	$V = \frac{E_e}{q_t} = \frac{kQ_s}{d}$ $E_e = q_t V$ $E_k = \frac{1}{2}mv^2$

Solution

a) Diagram



Solving using conservation of energy

$$E_{e_A} + E_{k_A} = E_{e_B} + E_{k_B}$$

$$q_e V_A + \frac{1}{2}m_e v_A{}^2 = q_e V_B + \frac{1}{2}m_e v_B{}^2$$

since $v_A = 0m/s$ and $V_A = 0V$

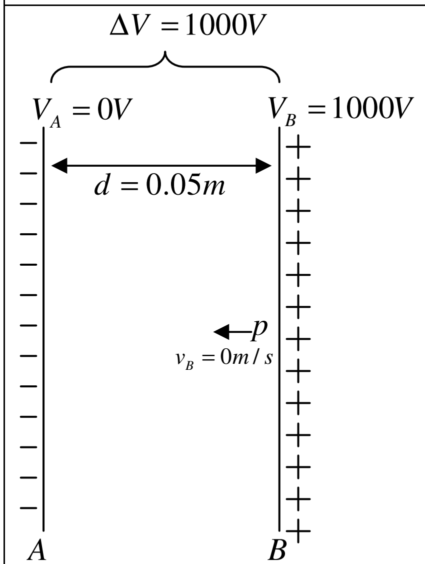
$$0 = q_e V_B + \frac{1}{2}m_e v_B{}^2$$

$$-q_e V_B = \frac{1}{2}m_e v_B{}^2$$

$$\sqrt{\frac{-2q_e V_B}{m_e}} = v_B$$

$$v_B = \sqrt{\frac{-2\left(-1.6\times10^{-19}\right)(1000)}{9.1\times10^{-31}}}$$

$$v_B = 1.87523\times10^7 m/s$$



Solving using conservation of energy

$$E_{e_A} + E_{k_A} = E_{e_B} + E_{k_B}$$

$$q_p V_A + \frac{1}{2}m_p v_A{}^2 = q_p V_B + \frac{1}{2}m_p v_B{}^2$$

since $v_B = 0m/s$ and $V_A = 0V$

$$\frac{1}{2}m_p v_A{}^2 = q_p V_B$$

$$v_A = \sqrt{\frac{2q_p V_B}{m_p}}$$

$$v_A = \sqrt{\frac{2\left(+1.6\times10^{-19}\right)(1000)}{1.67\times10^{-27}}}$$

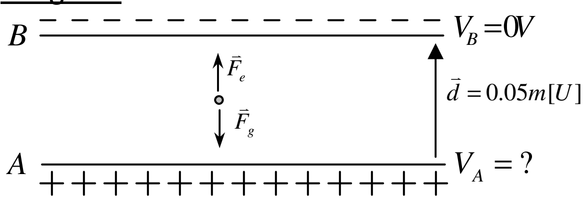
$$v_A = 4.37741\times10^5 m/s$$

5. Using a parallel plate apparatus, find the voltage required to balance a $1.0\times10^{-5}kg$ dust particle if the dust particle has a charge of $2.0\times10^{-6}C$ and the plates are separated by 5.0cm.

Given	RTF	Formula
$m=1.0\times10^{-5}kg$ $q=+2.0\times10^{-6}C$ $\vec{d}=0.05m[U]$	V	$\vec{\varepsilon}=\frac{\vec{F}_e}{q_t}, \vec{\varepsilon}=-\frac{\Delta V}{\vec{d}}, F_g=mg$

Solution

Diagram



The dust particle is in equilibrium.

$\therefore \vec{F}_{Net}=\vec{0}N$

$$\vec{F}_{Net}=\vec{F}_e+\vec{F}_g$$
$$0=+F_e-F_g$$
$$F_e=F_g$$
$$F_e=mg \quad (1)$$

Now consider the electric field.

$$\vec{\varepsilon}=\frac{\vec{F}_e}{q_t} \text{ but } F_e=mg$$
$$\vec{\varepsilon}=\frac{+mg}{q_t} \quad (2)$$

Now consider the electric field and the voltage

$$\vec{\varepsilon}=-\frac{\Delta V}{\vec{d}} \text{ sub in (2)}$$
$$\frac{+mg}{q_t}=-\frac{\Delta V}{\vec{d}}$$
$$\frac{+mg}{q_t}=-\frac{V_B-V_A}{\vec{d}} \text{ but } V_B=0V$$
$$\frac{+mg}{q_t}=-\frac{0-V_A}{\vec{d}}$$
$$\frac{+mg}{q_t}=\frac{V_A}{\vec{d}}$$
$$\frac{+mg\vec{d}}{q_t}=V_A$$
$$V_A=\frac{+\left(1.0\times10^{-5}\right)(9.8)(+0.05)}{+2.0\times10^{-6}}$$
$$V_A=2.45V$$