Physics Midterm

Andrea Iniguez
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2. Electric Charge & Electric Fields

#1

$E = \frac{KQ}{r^2}$

$K = 9 \times 10^9 NC^{-2}m^2 = \frac{1}{4\pi\varepsilon_0}$

$E = 2 \times 10^{-3} \frac{V}{m}$

$r = 1mm = 1 \times 10^{-3}$

a)

$$E = \frac{KQ}{r^2} \Rightarrow (2 \times 10^{-3}) = \frac{KQ}{(1 \times 10^{-3} m)^2} \Rightarrow KQ = 2 \times 10^{-9}$$

$$E = \frac{KQ}{r^2} \Rightarrow E = \frac{(2 \times 10^{-9})}{(5 \times 10^{-3})^2} = \frac{2 \times 10^{-9}}{25 \times 10^{-6}} = \boxed{8 \times 10^{-5} \frac{V}{C}}$$

* The E-field will decrease if the distance increases.

b)

$E = 8 \times 10^{-3}$

$Q = 1 \mu C = 1 \times 10^{-6}$

$Q = 3 \mu C = 3 \times 10^{-6}$

$K = \frac{1}{4\pi\varepsilon_0}$

$$E = \frac{KQ}{r^2} \Rightarrow E = \frac{1}{4\pi\varepsilon_0} \times \frac{Q}{r^2} \Rightarrow 8 \times 10^{-3} = \frac{1}{4\pi\varepsilon_0} \times \frac{1 \times 10^{-6}}{r^2} \Longrightarrow$$

$$\Rightarrow \frac{8 \times 10^{-3}}{1 \times 10^{-6}} = \frac{1}{4\pi\varepsilon_0 r^2} = 8 \times 10^{3}$$

$$E = \frac{KQ}{r^2} \Rightarrow E = \frac{1}{4\pi\varepsilon_0} \times \frac{Q}{r^2} \Rightarrow E = (8 \times 10^{3})(3 \times 10^{-6})$$

$$E = \boxed{2.4 \times 10^{-3} \frac{V}{C}}$$

* The e-field is proportional to the charge of object. If charge increases, then E-field increases too.

#2

(a)

$m = 4\times10^{-16}$ kg
$E = 6131.25$ N/C
$\vec{F} = qE$
$\vec{F} = mg$
$q_e = 1.6\times10^{-19}$ C
$q = ne$

$$\vec{F} = qE \quad \vec{F} = mg$$

$$qE = mg \Rightarrow q = \frac{mg}{E} \Rightarrow q = \frac{(4\times10^{-16}\text{ kg})(10\text{ m/s}^2)}{(6131.25\text{ N/C})}$$

$$\boxed{q = 6.52\times10^{-19}\text{ C}}$$

$$q = ne \Rightarrow n = \frac{q}{e} \Rightarrow \frac{6.52\times10^{-9}\text{ C}}{1.6\times10^{-19}\text{ C}} = \boxed{4.0\text{ electrons}}$$

(b)

$q = 6.52\times10^{-19}$ C
$q_e = 1.6\times10^{-19}$ C
$\vec{F} = qE$
$\vec{F} = ma$
$q = ne$
$m = 4\times10^{-13}$ g

$$\vec{F} = qE \quad \vec{F} = ma$$

$$qE = ma \Rightarrow a = \frac{qE}{m}$$

$$q - q_e$$
$$(6.52\times10^{-19}\text{ C}) - (1.6\times10^{-19}\text{ C})$$
$$q = 4.92\times10^{-19}$$

$$a = \frac{(4.92\times10^{-19}\text{ C})(6131.25\text{ N/C})}{4.10^{-13}\text{ kg}} = \boxed{7.5\times10^{-3}\text{ m/s}^2}$$

3. Potential Energy & Voltage, Capacitors

(a)

$E = q\Delta V$
$\Delta V = 4$ kV
$= 4\times10^{3}$ V
$H^+ = 1q_e$
$He = 2q_e$
$q_e = 1.6\times10^{-19}$ C

$$E = q\Delta V$$
$$E_{H^+} = (1.6\times10^{-19}\text{ C})(4\times10^{-3}\text{ V})$$
$$\boxed{E_{H^+} = 6.4\times10^{-16}\text{ J}}$$

$$E_{He} = (2\times1.6\times10^{-19}\text{ C})(4\times10^{-3}\text{ V})$$
$$\boxed{E_{He} = 12.8\times10^{-16}\text{ J}}$$

(b)

$E = \frac{\Delta V}{\Delta x}$

$\Delta x = 5\,cm$
$= 5\times10^{-2}\,m$

$E = \frac{\Delta V}{\Delta x} = \frac{4\times10^{-3}\,V}{5\times10^{-2}\,m}$

$\boxed{E = 8\times10^{4}\,V/m}$

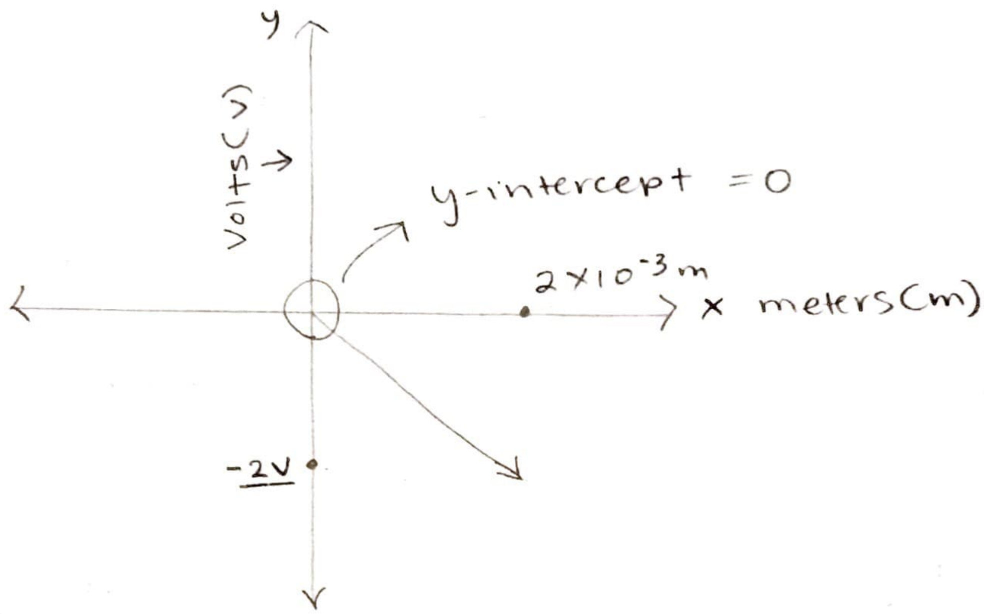
#2

$E = 1kV$
$E = 1000\,V/m$

$d = 2mm$
$= 2\times10^{3}\,m$

$E = (-)\frac{\Delta V}{\Delta x}$

$\Delta V = -E\Delta x$
$\Delta V = -(1000)(2\times10^{-3})$
$\Delta V = \underline{-2V}$



#3

(a)

$C = \frac{\varepsilon_0 A}{d}$

$A = 1mm^2$
$= 1\times10^{-4}\,m$

$d = 2mm$
$d = 2\times10^{3}\,m$
$\varepsilon_0 = 8.85\times10^{-12}\,F/m$

$C = \frac{(8.85\times10^{-12}\,F/\cancel{m})(1\times10^{-4})}{2\times10^{-3}\,\cancel{m}}$

$C = \boxed{4.4\times10^{-13}\,F}$

(b)

$E = \frac{1}{2}CV^2$
$V = 5V$

$E = \frac{1}{2}(4.4\times10^{-13}F)(5)^2$

$E = \frac{1}{2}(4.4\times10^{-13}F)(25)$

$\boxed{E = 5.5\times10^{-12}\,J}$

#4

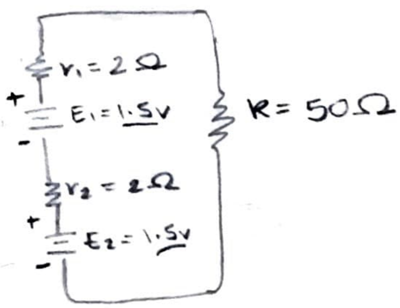
If we want more capacitance, we should Connect Capacitors in parallel. When in parallel the total Capacitance is the sum of the individual capacitor's capacities thus, increasing capacitance.

4. Currents, Resistance & DC Circuits

#1

(a)

serial Case ⇒ $I = ?$



$\mathcal{E} = I(r+R) = I_{r\ tot}$

$-\mathcal{E} + I_2 R_2 = 0$

$-\mathcal{E} + I_1 R_1 = 0$

$+E_2 + I_2 r_2 - \mathcal{E}_1 + I_1 r_1$

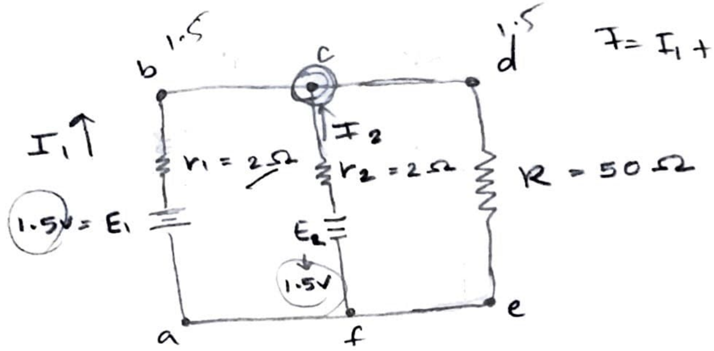
$-1.5 + I(r_1 r_2 + R) - 1.5V = 0$

$I = \frac{V}{r_1 r_2 R} = \frac{3V}{2+2+50\Omega}$

$I = \boxed{0.055\text{ Amp} \quad 55.5\text{ mAmp}}$

Parallel case ⇒ $I = ?$

$I = I_1 + I_2$



$V = IR \rightarrow I = \frac{V}{R}$

$50\left(\frac{V_{r_1} - 1.5}{2\Omega} + \frac{V_{r_2} - 1.5}{2\Omega}\right) + \frac{V_r}{50\Omega} = 0$

$\frac{25V_{r_1} - 37.5 + 25V_2 - 37.5 + V_R}{50\Omega}$

$V = 1.47V$

$I_1 = \frac{V}{r_1} = \frac{1.5V - 1.47V}{2\Omega}$

$I_1 = \boxed{0.015\text{ Amp}}$

$I_2 = \frac{V}{r_2} = \frac{1.5V - 1.47V}{2\Omega}$

$I_2 = \boxed{0.015\text{ Amp}}$

$I = 0.015 + 0.015 = \boxed{0.03\text{ Amp} \quad 30.0\text{ mAmp}}$

(b)

Serial Case $\Rightarrow P = ?$

$P_{tot} = P_1 + P_2 + P$

$P = IR \rightarrow P = I^2R$
Power loss

$P = I_1^2 r_1 + I_2^2 r_2 \; I^2 R$

$P = (0.055\,Amp)^2(2\Omega) + (0.055\,amp)^2(2\Omega) + (0.055\,amp)(50\Omega)$

$P = 0.00605 + 0.00605 + 0.15125$

$$\boxed{\begin{aligned} P &= 0.16335\,W \\ &= 163.35\,mWatts \end{aligned}}$$

Parallel Case $\Rightarrow P = ?$

$P = I^2 R$

$P = I_1^2 r_1 + I_2^2 r_2 + I^2 R$

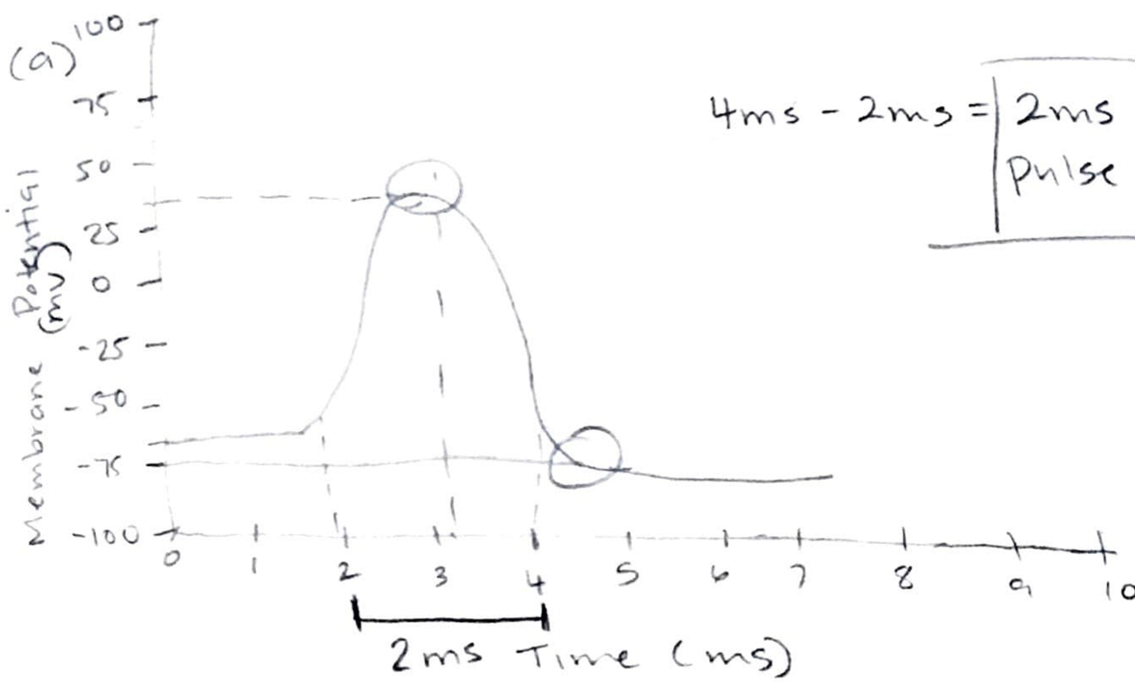
$P = (0.015\,Amp)^2(2\Omega) + (0.015\,Amp)(2\Omega) + (0.03\,Amp)50\Omega$

$P = 0.00045 + 0.00045 + 0.045$

$$\boxed{\begin{aligned} P &= 0.0459\,Watts \\ &= 45.9\,mWatts \end{aligned}}$$

#2

(a)



$4ms - 2ms = \boxed{2ms}$
Pulse width

(b) Peak - to - peak
greatest - least

$40mv - (-75mv) \rightarrow 40mv + 75mv = \boxed{115mV}$