# Physics Midterm

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## 2. Electric Charge & Electric Fields

#1

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

$K = 9\times10^{9}\ N C^{-2} m^2 = \frac{1}{4\pi\varepsilon_0}$

$E = 2\times10^{-3}\ \frac{V}{m}$

$r = 1mm = 1\times10^{-3}$

a)

$E = \frac{KQ}{r^2} \Rightarrow (2\times10^{-3}) = \frac{KQ}{(1\times10^{-3}\,m)^2} \Rightarrow KQ = 2\times10^{-9}$ ✓

$E = \frac{KQ}{r^2} \Rightarrow E = \frac{(2\times10^{-9})}{(5\times10^{-3})^2} = \frac{2\times10^{-9}}{25\times10^{-6}} = \boxed{8\times10^{-5}\ \frac{V}{C}}$

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

b)

$E = 8\times10^{-3}$

$Q = 1MC = 1\times10^{-6}$

$Q = 3MC = 3\times10^{-6}$

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

$E = \frac{KQ}{r^2} \Rightarrow E = \frac{1}{4\pi\varepsilon_0} \times \frac{Q}{r^2} \Rightarrow 8\times10^{-3} = \frac{1}{4\pi\varepsilon_0} \times \frac{1\times10^{-6}}{r^2} \Longrightarrow$

$\Rightarrow \frac{8\times10^{-3}}{1\times10^{-6}} = \frac{1}{4\pi\varepsilon_0 r^2} = 8\times10^{3}$

$E = \frac{KQ}{r^2} \Rightarrow E = \frac{1}{4\pi\varepsilon_0} \times \frac{Q}{r^2} \Rightarrow E = (8\times10^{3})(3\times10^{-6})$

$E = \boxed{2.4\times10^{-3}\ \frac{V}{C}}$ ✓

* 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
$q = ne$

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

Well done

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

$q = 6.52\times10^{-19}$ C ✓

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

$\vec{F} = qE \quad \vec{F} = ma$ (-1)

the mass is $4\times10^{-16}$ kg

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

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

$a = \frac{(4.92\times10^{-19})(6131.25\text{ N/C})}{4.10^{-13}\text{ kg}} =$ **$7.5\times10^{-3}$ m/s²**

2.45 m/s²

## 3. Potential Energy & Voltage, Capacitors

(a)

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

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

$E_{H^+} = 6.4\times10^{-16}$ J ✓

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

$E_{He} = 12.8\times10^{-16}$ J ✓

(b)

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

$\Delta x = 5\,cm = 5 \times 10^{-2} m$

$E = \frac{\Delta V}{\Delta x} = \frac{4 \times 10^{-3} V}{5 \times 10^{-2} m}$

$E = 8 \times 10^{4}\ V/m$ ✓

#2

$E = 1kV$ ↓

$E = 1000\ V/m$

$d = 2mm$ ↓

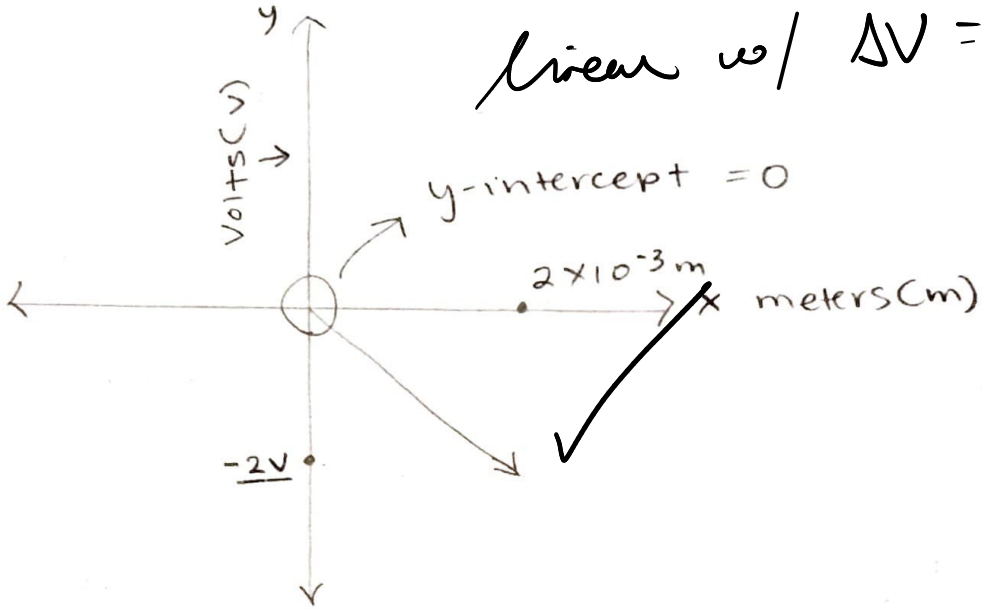
$= 2 \times 10^{-3} m$

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

$\Delta V = -E \Delta x$

$\Delta V = -(1000)(2 \times 10^{-3})$

$\Delta V = \underline{-2V}$




linear w/ $\Delta V = 2$ volt

#3

(a)

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

$A = 1mm^2 = 1 \times 10^{-4} m$

$d = 2mm$

$d = 2 \times 10^{-3} m$

$\varepsilon_0 = 8.85 \times 10^{-12} F/m$

$C = \frac{(8.85 \times 10^{-12} F/m)(1 \times 10^{-4})}{2 \times 10^{-3} m}$

$C = 4.4 \times 10^{-13} F$ ✓

great job!

(b)

$E = \frac{1}{2} C V^2$

$V = 5V$

$E = \frac{1}{2} (4.4 \times 10^{-13} F)(5)^2$

$E = \frac{1}{2} (4.4 \times 10^{-13} F)(25)$

$E = 5.5 \times 10^{-12} J$ ✓ 5 pJ

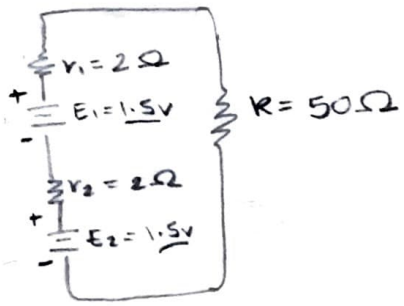
#4

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 ⇒ $I = ?$




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

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

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

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

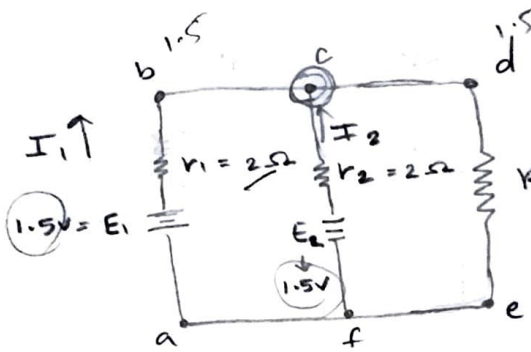
$-1.5 + I(r_1 r_2 + R) - 1.5V = 0$

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

$I = \boxed{0.055\ \text{Amp} \\ 55.5\ \text{m Amp}}$

Parallel case ⇒ $I = ?$

$I = I_1 + I_2$




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

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

$\frac{25V_1 - 37.5 + 25V_2 - 37.5 + V_R}{50\Omega}$

$V = 1.47V$

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

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

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

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

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

(b)

Serial Case ⇒ P = ?

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

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

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

$P = (0.055\,Amp)^2(2\Omega) + (0.055\,amp)^2(2\Omega) + (0.05\,amp)(50\Omega)$

$P = 0.00605 + 0.00605 + 0.15125$

$P = 0.16335\,W$
$= 163.35\,mWatts$ ✓

Parallel Case ⇒ P = ?

$P = I^2R$

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

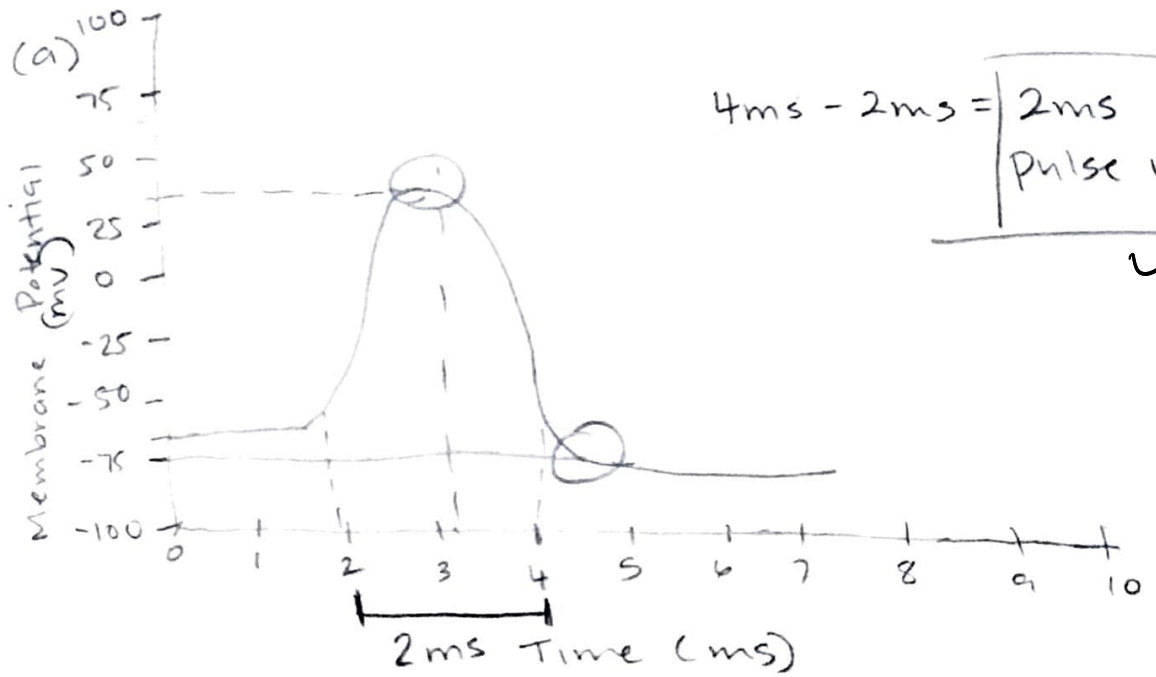
$P = (0.015\,Amp)^2(2\Omega) + (0.015\,Amp)(2\Omega) + (0.03\,Amp)50\Omega$

$P = 0.00045 + 0.00045 + 0.045$

$P = 0.0459\,Watts$
$= 45.9\,mWatts$ ✓

#2

(a)




4ms − 2ms = 2ms pulse width ✓

(b) Peak-to-peak

greatest − least

40mv − (−75mv) → 40mv + 75mv = 115mV ✓