FOUN10111 | World of the Electron | Pavel Ghazaryan
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25/01/2021

Written - answer paper

1/ $q_1 = q_2 = q = +9,6 \cdot 10^{-12} C$
$d = 4,5 \cdot 10^{-6} m$
$\varepsilon_r = 78,0$

$F - ?$

$F = k \frac{q^2}{r^2}$

$k = \frac{1}{4\pi\varepsilon}$ where $\varepsilon = \varepsilon_r \varepsilon_0 = 8,85 \cdot 10^{-12} \cdot 78$

therefore $\Rightarrow F = \frac{1 \cdot 9,6^2 \cdot 10^{-24}}{4 \cdot \pi \cdot 8,85 \cdot 78 \cdot 10^{-12} \cdot 4,5^2 \cdot 10^{-12}} =$

$= \frac{92,16 \cdot 10^{-24} \cdot 10^{24}}{690,3 \cdot 81 \cdot \pi} = 5,2465 \cdot 10^{-4} \approx$

$\approx \underline{5,25 \cdot 10^{-4} N}$

2/ $d = 34 \cdot 10^{-3} m$
$q = +3e$
$W = 218 eV = 218 \cdot 1,6 \cdot 10^{-19} J$

$E - ?$

$V = \frac{W}{q} = \frac{218 \cdot 1,6 \cdot 10^{-19}}{3 \cdot 1,6 \cdot 10^{-19}} =$

$= 72,666 \approx 72,7 V$

$E = \frac{V}{d} = \frac{72,7}{34 \cdot 10^{-3}} = 2,1382 \cdot 10^3 \approx$

$\approx \underline{2,14 \cdot 10^3} N C^{-1} = \underline{2,14 \cdot 10^3 N C^{-1}}$

As the Electric field is uniform its field strength is the same at any point.

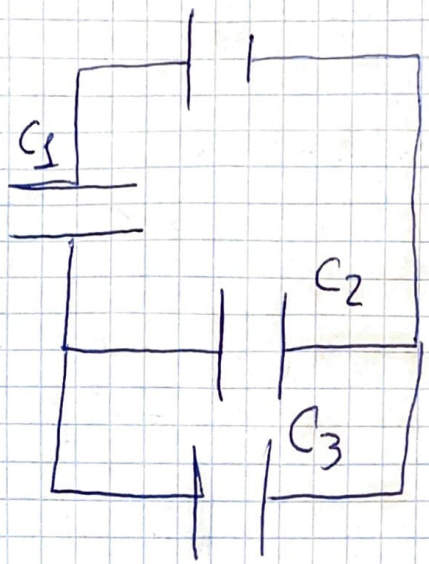
3/

$V = 3\,V$

$Q = 30 \cdot 10^{-6}\,C$

$C_2 = 8 \cdot 10^{-6}\,F$

$C_3 - ?$



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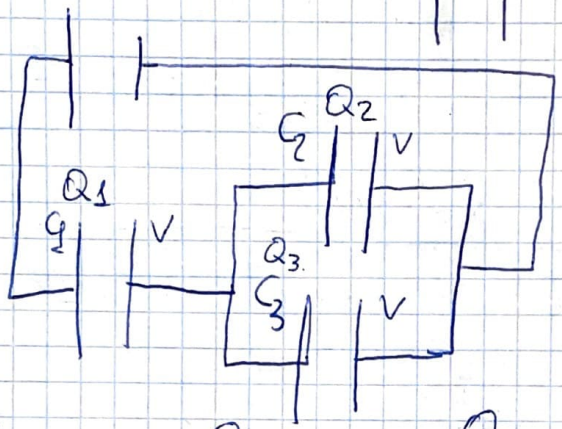


$C_1 = \frac{Q_1}{V} \quad C_2 = \frac{Q_2}{V} \quad C_3 = \frac{Q_3}{V}$

As C_1 is in series to C_2 and C_3 $\Rightarrow Q_1 = Q_2 + Q_3 \Rightarrow$

$\Rightarrow Q = Q_1 + Q_2 + Q_3 = 2 \cdot (Q_2 + Q_3) \Rightarrow$

$C_2 = \frac{Q_2}{V} \Rightarrow 8 \cdot 10^{-6} \cdot 3 = Q_2 = 24 \cdot 10^{-6}\,C$

$\Rightarrow 30 \cdot 10^{-6}\,C = 2 \cdot (24 \cdot 10^{-6} + Q_3)$

$15 \cdot 10^{-6} -$

$Q_1 + Q_2 + Q_3 = Q \Rightarrow Q = Q_2 + Q_3 + Q_2 + Q_3 =$

$Q_2 + Q_3 = 15 \cdot 10^{-6}\,C. \qquad = 2 \cdot (Q_2 + Q_3)$

$C_2 \cdot V = Q_2 = 24 \cdot 10^{-6} \Rightarrow Q_3 = 9 \cdot 10^{-6}\,C \Rightarrow$

$\Rightarrow C_3 = \frac{9 \cdot 10^{-6}}{3} = 3 \cdot 10^{-6}\,F \approx 3{,}00\,\mu F$

4/ $L = 5,25\,m = 5,25\,m$
$r = 0,3 \cdot 10^{-3}\,m$
$R = 2,56\,\Omega$

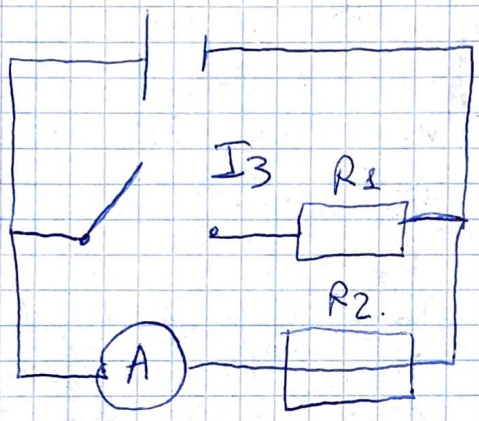
$R = \rho \frac{l}{A} = \rho \cdot \frac{5,25}{\pi \cdot 0,3^2 \cdot 10^{-6}} \Rightarrow$

$\rho - ?$ $\Rightarrow \rho = \frac{2,56 \cdot 0,09 \cdot 10^{-6}}{5,25} =$

$= 0,04388 \cdot 10^{-6} \approx 0,0438 \cdot 10^{-6} = \underline{\underline{4,38 \cdot 10^{-8}\,\Omega m}}$

5/ $R_1 = 12\,\Omega$
$R_2 = 4,00\,\Omega$
$I_1 = 4,66\,A$
$I_2 = 4,34\,A$

$r - ?$



from first case when switch is open no current goes to R_1 so $\Rightarrow$

$\Rightarrow \mathcal{E} = I_1 \cdot (R_2 + r)$

When switch closes R_1 and R_2 are parallel $\Rightarrow V_1 = V_2$ for resistors so $\Rightarrow$ $I_3 R_1 = I_2 R_2 \Rightarrow I_3 = \frac{4,34 \cdot 4}{12} = 1,45\,A$

$\Rightarrow \mathcal{E} = (I_2 + I_3) \cdot \left(\frac{R_1 \cdot R_2}{R_1 + R_2} + r \right) \Rightarrow$

$\mathcal{E} = I_1 \cdot (R_2 + r)$

$\Rightarrow 5,79 \cdot (3 + r) = 4,66 \cdot (4 + r) \Rightarrow$

$\Rightarrow 17,37 + 5,79r = 18,64 + 4,66r$

$1,13r = 1,27$

$r = 1,1238 \approx \underline{\underline{1,12}}\,\Omega$

6/ $N = 65$
$L = 10^{-1}\ m$
$I = 0{,}750\ A$
$B = 135 \cdot 10^{-3}\ T$

$\mu_r - ?$

$B = \frac{N}{L} \cdot \mu_r \cdot \mu_0 \cdot I$

$\mu_r = \frac{BL}{N \cdot \mu_0 \cdot I} = \frac{135 \cdot 10^{-3} \cdot 10^{-1}}{65 \cdot 4\pi \cdot 10^{-7} \cdot 0{,}75} =$

$= 0{,}22036 \cdot 10^3 = \underline{\underline{220\ NA^{-2}}}$

7/ $A = 350 \cdot 10^{-4}\ m^2$
$N = 425$
$B = 10{,}1 \cdot 10^{-3}\ T$
$N_S = 3N_P$
$\mathcal{E}_{RMS} = 120\ V$

$f - ?$

$\mathcal{E}_{rms} = \frac{\mathcal{E}_{peak}}{\sqrt{2}}$

We will get $\mathcal{E}_{peak}$ when the output of AC generator is the biggest. Therefore

$\mathcal{E} = NBA\,2\pi f\,(\cos\Theta^{\text{for max}} = 1) =$

$= \mathcal{E}_p$ (The emf is primary for transformer) $\Rightarrow$

$\Rightarrow \frac{\mathcal{E}_p}{\mathcal{E}_{PEAK}} = \frac{N_P}{N_S} \Rightarrow \frac{\mathcal{E}_p}{\mathcal{E}_{PEAK}} = \frac{N_P}{3N_P} \Rightarrow \mathcal{E}_{PEAK} = 3\mathcal{E}_p \Rightarrow$

$\Rightarrow \mathcal{E}_{RMS} = \frac{3\mathcal{E}_p}{\sqrt{2}} \Rightarrow \frac{\sqrt{2}}{3} \cdot \mathcal{E}_{RMS} = NBA\,2\pi f \Rightarrow$

$\Rightarrow f = \frac{\frac{\sqrt{2}}{3} \cdot \mathcal{E}_{RMS}}{NBA2\pi} = \frac{\sqrt{2} \cdot 120}{3 \cdot 425 \cdot 10{,}1 \cdot 10^{-3} \cdot 350 \cdot 10^{-4} \cdot 2 \cdot \pi} =$

$= 5{,}99262 \cdot 10^{-6} \cdot 10^7 = 59{,}826 \approx$

$\approx \underline{\underline{59{,}9\ Hz}} \approx 60{,}0\ Hz$

8/

$E = 2500\ V m^{-1}$

$B = 65 \cdot 10^{-3}\ T$

$\alpha = 90°$

E_k - ?

$F = qvB\sin\alpha = qvB(\sin 90° = 1)$ and $q = e$

$F = evB$

But $F = qE = eE \Rightarrow$

$\Rightarrow eE = evB$

$$v = \frac{E}{B} = \frac{2500}{65 \cdot 10^{-3}} = 38{,}461 \cdot 10^{3}\ m s^{-1}$$

$$E_k = \frac{mv^2}{2} = \frac{m_e v^2}{2} = \frac{9{,}11 \cdot 10^{-31} \cdot 1479{,}2899 \cdot 10^{6}}{2} =$$

$$= 6738{,}165 \cdot 10^{-25} \approx \underline{\underline{67{,}4 \cdot 10^{-23}\ J}}$$

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