UNIVERSITY OF GAZIANTEP DEPARTMENT OF ENGINEERING PHYSICS EP 106 General Physics II Second Midterm Exam *FALL SEMESTER*	
Date: 02/05/2019 Time: 10:30 Duration: 90 min.	

EDUCATION : ☐ 1^{st} Ed. ☐ 2^{nd} Ed.
DEPARTMENT : ☐ CE ☐ MME ☐ IE ☐ ME ☐ TE

Name	Surname	Student No	Signature
—	S O L U T I O N S		—

Ques.	Mark
1	
2	
3	
4	
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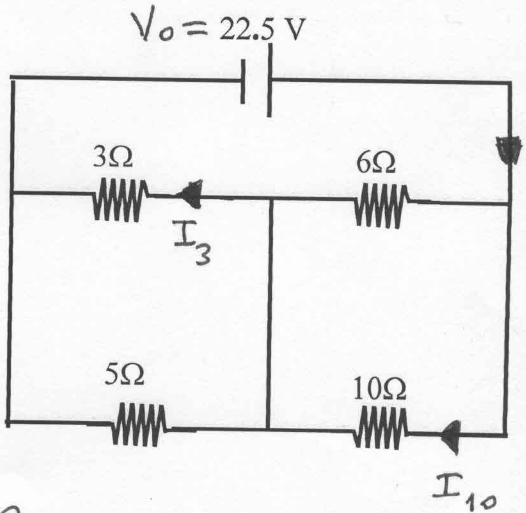
Total	

- Cheating is a serious offence and may lead to your dismissal from the university.
- Ignore air resistance in all problems unless otherwise stated.
- Write clearly your solutions steps to the space provided and results to the boxes.
- Constants: π=3.14, k= $9x10^9$ N.m^2/C^2, ε_o = 8.85x10^{-12} C^2/N.m^2, m_e=9.1^{-31} kg,|e|=1.6x10^{-19} C, μ_o= 4πx10^{-7}T.m/A
- 1 mm=10^{-3} m,1 cm= 10^{-2} m,1nm =10^{-9} m, 1 pm = 10^{-12} m,1 h = 3600 s,1 min = 60 s, 1 rev = 2π rad.

QUESTION 1 (20 %)

Find the voltage across and current through 3 Ω and 10 Ω resistors in the given figure.



- 3 Ω and 5 Ω are parallel to each other

$$R_{35} = \frac{3 \times 5}{3+5} = 1.875\ \Omega$$

- 6 Ω and 10 Ω are parallel to each other:

$$R_{6.10} = \frac{6 \times 10}{6+10} = 3.75\ \Omega$$

- Total (equivalent resistance) = $R_{35} + R_{6.10} = 5.625\ \Omega$

Total current in the circuit: $I_T = \frac{V_o}{R_{eq}} = \frac{22.5}{5.625} = 4\ A.$

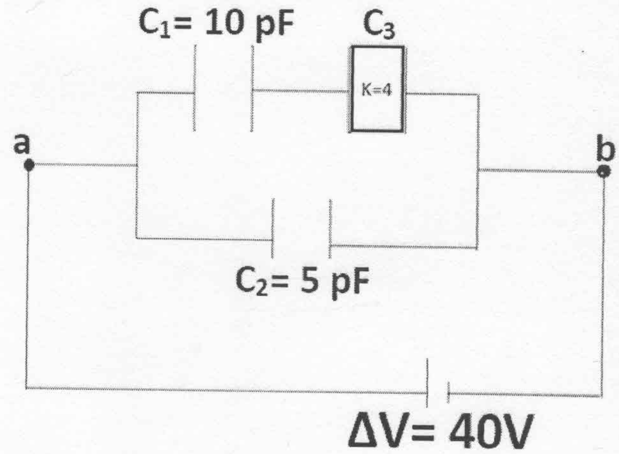
Current divider rule:

$$I_{10} = \left(\frac{6}{6+10}\right) I_T = \frac{6}{16}(4) = 1.5\ A \Rightarrow V_{10} = I_{10}\, 10 = (1.5)(10) = 15\ V$$

$$I_3 = \left(\frac{5}{3+5}\right) I_T = \frac{5}{8}(4) = 2.5\ A \Rightarrow V_3 = (2.5)(3) = 7.5\ V$$

$I_3 = 2.5\ A$	$I_{10} = 1.5\ A$
$V_3 = 7.5\ V$	$V_{10} = 15.0\ V$

QUESTION 2 (20 %)
For the given circuit;



(a) Find the capacitance value of third capacitor (C_3) if the distance between plates is 8.85 mm and area of each plate is $25\text{x}10^{-4}$ m^2.

$$C_3 = \frac{\varepsilon_0 A}{d} k$$

$$= \frac{(8.85\times10^{-12})(25\times10^{-4})}{8.85\times10^{-3}}(4)$$

$$= 10\times10^{-12}\ F \Rightarrow C_3 = 10\,pF$$

$C_3 = 10\,pF$

(b) Find the equivalent capacitance value between points "a" and "b".

$$C_{13} = \frac{C_1 C_3}{C_1 + C_3} = \frac{(10)(10)}{10+10} = 5\,pF$$

$$C_{eq} = C_{13} + C_2 = 5+5 = 10\,pF$$

$C_{eq} = 10\,pF$

(c) Find the total charge on the second capacitor (C_2).

$$Q_2 = C_2\,\Delta V = (5)(40) = 200\,pC$$

$$= 200\times10^{-12}\ C$$

$Q_2 = 200\,pC$

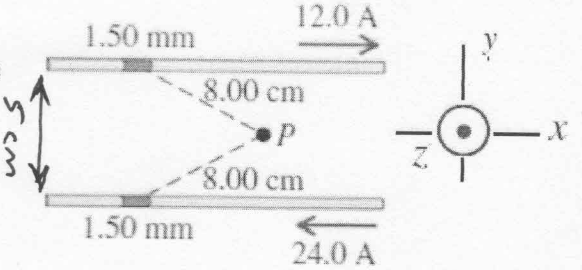
(d) Find the potential energy stored in the second charged capacitor (C_2).

$$U_2 = \frac{Q_2^2}{2C_2} = \frac{(200\times10^{-12})^2}{(2)(5\times10^{-12})} = 4\times10^{-9}\ J$$

$U_2 = 4\times10^{-9}\ J$

QUESTION 3 (20 %)

Two parallel wires are 5 cm apart and carry currents in opposite directions, as shown. Find the magnitude and direction of the total magnetic field at point P due to two 1.50 mm segments of wire. [The distance from each segment to the point P is 8 cm].



magnetic field due to small current element is:

$$dB = \frac{\mu_0 I}{4\pi} \frac{dl \sin\theta}{r^2}$$

$dl = 1.5\text{ mm}$

$\sin\theta = \frac{2.5}{8} = 0.3125$

$r = 8\text{ cm}$

Top wire:

$$dB_1 = \frac{4\pi\times10^{-7}(12)}{4\pi} \frac{(1.5\times10^{-3})(0.3125)}{(0.08)^2} = 8.79\times10^{-8}\,T \ \otimes$$

Bottom wire:

$$dB_2 = \frac{4\pi\times10^{-7}(24)}{4\pi} \frac{(1.5\times10^{-3})(0.3125)}{(0.08)^2} = 1.75\times10^{-7}\,T \ \otimes$$

Total $dB_t = dB_1 + dB_2 = 2.64\times10^{-7}\,T \ \otimes$ $\boxed{dB_t = 2.64\times10^{-7}\,T}\ (-\hat{z})$

QUESTION 4 (20 %)

A cylindrical copper wire having diameter 6 mm and length 20 m carries a currecnt of 8 A. The wire is initially operating at room temperature at T= 20 °C.

(a) What is the current density in the wire?

$D = 6\text{ mm} \Rightarrow r = 3\text{ mm}$

$$J = \frac{I}{A} = \frac{I}{\pi r^2} = \frac{8}{\pi(3\times10^{-3})^2} = 2.8\times10^{+5}\ A/m^2$$

$$= 2.8\times10^{-1}\ A/mm^2$$

$\boxed{J = 2.8\times10^{5}\ A/m^2}$

(b) Find the drift speed of the electrons in the wire if there are $n = 8.9 \times 10^{28}$ electrons/m^3.

$$v_d = \frac{J}{ne} = \frac{2.8\times10^{5}}{(8.9\times10^{28})(1.6\times10^{-19})} = 2\times10^{-5}\ m/s$$

$\boxed{v_d = 2\times10^{-5}\ m/s}$

(c) What is the resistance of the wire at T = 100 °C [$\alpha = 3.9\times10^{-3}$ 1/°C, $\rho = 1.7\times10^{-8}$ Ω.m at T = 20 °C]

Resistance at $T = 20°C$

$$R = \rho\frac{L}{A} = (1.7\times10^{-8})\left(\frac{20}{\pi(3\times10^{-3})^2}\right) = 1.2\times10^{-2}\,\Omega$$

$$= 0.012\,\Omega$$

at $T = 100°C$

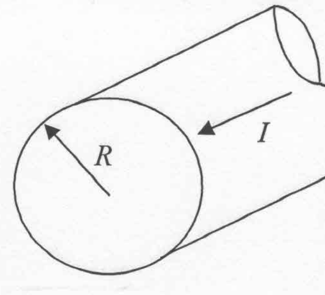
$\boxed{R_{100} \approx 0.016\,\Omega}$

$$R = R_0[1 + \alpha(T - T_0)]$$

$$= 0.012[1 + 3.9\times10^{-3}(100-20)] = 0.0157\,\Omega$$

QUESTION 5 (20 %)

A long straight cylindrical conducting wire of radius R carries a current I of a uniform current density.



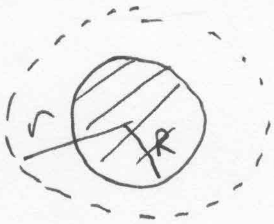
(a) Determine the magnetic field at a radial distance r from the axis of the wire for $r > R$.

Ampere's law:

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{enc}$$

$$B(2\pi r) = \mu_0 I$$

$$B = \frac{\mu_0 I}{2\pi r} \qquad r > R$$



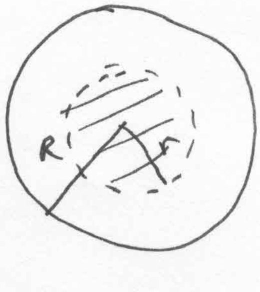
$$\boxed{B = \mu_0 I / 2\pi r}$$

(b) Determine the magnetic field at a radial distance r from the axis of for $r < R$.

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{enc}$$

$$B(2\pi r) = \mu_0 \frac{\pi r^2}{\pi R^2} I$$

$$B = \frac{\mu_0 I}{2\pi} \left(\frac{r}{R^2} \right) \qquad r < R$$



$$\boxed{B = \mu_0 I r / (2\pi R^2)}$$

(c) Calculate the magnetic fields numerically at $r = 5$ mm and $r = 2$ mm if the radius of the wire is $R = 3.5$ mm and the current is $I = 25$ A.

$$B(5\,\text{mm}) = \frac{(4\pi \times 10^{-7})(25)}{(2\pi)\, 5 \times 10^{-3}} = 1 \times 10^{-3}\ T$$

$$B = \begin{cases} \dfrac{\mu_0 I}{2\pi r} & r > R \\ \dfrac{\mu_0 I r}{2\pi R^2} & r < R \end{cases}$$

$$B(2\,\text{mm}) = \frac{(4\pi \times 10^{-7})(25)(2 \times 10^{-3})}{(2\pi)(3.5 \times 10^{-3})^2} = 8.16 \times 10^{-4}\ T$$

$$\boxed{B_{out} = 1 \times 10^{-3}\ T} \qquad \boxed{B_{in} = 8.16 \times 10^{-4}\ T}$$