Inspiring Excellence

BRAC UNIVERSITY

Principles of Physics-II (PHY-112)

Department of Mathematics and Natural Sciences

Quiz: 03, **Section**: 6/8

Date: April 3, 2024

Duration: 30 Minutes | **Spring 2024 (10F-31C)** | Marks: 15

Name: Student ID:

Use SI Units only. Partial Marks will be given for partially correct answers ONLY.

1. You turn on a switch for a light-bulb 20 m away. The electron drift speed in the circuit (diameter 1.0 mm) is 5.0 µm s^{-1}. Which of the following generates a current in the wire? — **(1)**

   ◯ Random motion of the free electrons ◯ Drift motion ◯ Current Density ◯ Positive charges

2. A dielectric material with $\kappa = -0.5$ will decrease the potential difference between the capacitor plates by — **(1)**

   ◯ half ◯ one-third ◯ undefined parameters ◯ V remains the same

3. A parallel plate capacitor consists of two plates of equal area A, separated by an air gap of amount d. If a dielectric of permittivity κ is inserted between what would be its capacitance — **(1)**

   ◯ $\frac{\epsilon_0 A}{d}$ ◯ $\frac{\kappa\epsilon_0 A}{d}$ ◯ $\frac{\kappa A}{d}$ ◯ $\frac{\epsilon A}{d}$

4. Take $A = 200\,\text{cm}^2$, $d = 0.400\,\text{cm}$. If the capacitor is connected across a 500 V source, the value outside the plates is — **(1)**

   ◯ $0\,\text{N C}^{-1}$ ◯ $125\,\text{kV m}^{-1}$ ◯ $125\,\text{kN C}^{-1}$ ◯ (c) and (d)

5. A capacitor with 5 µF capacitance can store 650 J energy. How much charge can it store on the plate connected to the positive plate? The plates are separated by a dielectric of permittivity $50 \times 10^{-12}\,\text{F m}^{-1}$ — **(1)**

   ◯ $-80.62\,\text{mC}$ ◯ $80.62\,\text{mC}$ ◯ $\pm 80.62\,\mu\text{C}$ ◯ $0\,\mu\text{C}$

6. A parallel plate capacitor has a potential difference of 15 V and a plate separation of 5 mm. A dielectric slab with $\kappa = 10$ is placed between the plates. What is the ratio of the capacitance before and after the placement of the dielectric? Find also the permittivity of the dielectric material. **(3)**

$C_{old} : C_{new} = \frac{1}{\kappa}$.

No math required!

7. A Nichrome wire of diameter 0.98 m and length 1 m carries a constant current of 0.26 A to a 60 W bulb. The free-electron density in the wire is 9×10^{28} per cubic meter. The Nichrome wire conductivity is $6.7 \times 10^{5} \Omega^{-1}\,\mathrm{m}^{-1}$. Find (a) the $\vec{E}$ field strength inside the wire, (b) the drift speed, and (c) explain the physical significance of Ohm's law in 3D, in the context of an electric circuit. **(4)**

(a) $E = \rho J = \frac{1}{\sigma} \times \frac{I}{A} = \frac{I}{\sigma \frac{\pi d^2}{4}}$.

$I = 0.26\,A, \; d = 0.98\,m$.

$\sigma = 6.7 \times 10^{5} \Omega^{-1} m^{-1}$.

(b) $v_d = \frac{J}{nq} = \frac{I}{\frac{\pi d^2}{4} \times nq}$.

(c) $\vec{J} = \sigma \vec{E}$; Electric field establishes a current density linearly dependent.

8. What diameter must a Copper wire have if its resistance is to be the same as that of an equal length of Aluminum wire with diameter 4 mm? The resisivities for Copper and Aluminum wire are $1.68 \times 10^{-8}\,\Omega\,\mathrm{m}$ and $2.80 \times 10^{-8}\,\Omega\,\mathrm{m}$ respectively. **(3)**

$R_{Cu} = R_{Al}$

$\frac{\rho_{Cu} L_{Cu}}{A_{Cu}} = \frac{\rho_{Al} L_{Al}}{A_{Al}}$

$A_{Cu} = \frac{\rho_{Cu}}{\rho_{Al}} \times A_{Al}$

$d_{Cu}^2 = \frac{\rho_{Cu}}{\rho_{Al}} \times d_{Al}^2$

$d_{Cu} = \sqrt{\frac{\rho_{Cu}}{\rho_{Al}}}\, d_{Al}$

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1. You turn on a switch for a light-bulb 20 m away. The electron drift speed in the circuit (diameter 1.0 mm) is 5.0 × μm s^{-1}. Which of the following is NOT required to generate a current in the wire? — **(1)**

   ◯ Potential difference ◯ Drift motion ◯ Electric field ◯ Energy exchange

2. A dielectric material with $\kappa = 0.5$ will decrease the potential difference between the capacitor plates by — **(1)**

   ◯ half ◯ one-third ◯ undefined parameters ◯ V remains the same

3. A parallel plate capacitor consists of two plates of equal area A, separated by an air gap of amount d. If a dielectric of permittivity κ is inserted between, what would be its capacitance — **(1)**

   ◯ $\frac{\epsilon_0 A}{d}$ ◯ $\frac{\kappa\epsilon_0 A}{d}$ ◯ $\frac{\kappa A}{d}$ ◯ $\frac{\epsilon A}{d}$

4. Take $A = 200\,\text{cm}^2$, $d = 0.400\,\text{cm}$. If the capacitor is connected across a 500 V source, the value outside the plates is — **(1)**

   ◯ $0\,\text{N C}^{-1}$ ◯ $125\,\text{kV m}^{-1}$ ◯ $125\,\text{kN C}^{-1}$ ◯ (c) and (d)

5. A capacitor with 2 μF capacitance can store 650 J energy. How much net charge can it store? The plates are separated by a dielectric of permittivity $120 \times 10^{-12}\,\text{F m}^{-1}$ — **(1)**

   ◯ $-50.99\,\text{mC}$ ◯ $50.99\,\text{mC}$ ◯ $\pm 50.99\,\mu\text{C}$ ◯ $0\,\mu\text{C}$

6. A parallel plate capacitor has a potential difference of 15 V and a plate separation of 5 mm. A dielectric slab with $\kappa = 10$ is placed between the plates. What is the ratio of the capacitance before and after the placement of the dielectric? Find also the permittivity of the dielectric material. **(3)**

$C_{old} : C_{new} = \frac{1}{\kappa}$.

No math required!

7. A Platinum wire of diameter 0.98 m and length 1 m carries a current of 0.26 A. The free-electron density in the wire is 10×10^{28} per cubic meter. The Platinum wire conductivity is $9.43 \times 10^{6} \Omega^{-1}\,\mathrm{m}^{-1}$. Find (a) the $\vec{E}$ field strength inside the wire, (b) the drift speed, and (c) explain the physical significance of Ohm's law in its experimental form. **(4)**

(a) $E = \rho J = \frac{1}{\sigma} \times \frac{I}{A} = \frac{I}{\sigma \frac{\pi d^2}{4}}$.

$I = 0.26\,A$, $d = 0.98\,m$.

$\sigma = 9.43 \times 10^{6}\,\Omega^{-1}\,m^{-1}$.

(b) $v_d = \frac{J}{nq} = \frac{I}{\frac{\pi d^2}{4} \times nq}$.

(c) $I = \frac{\Delta V}{R}$; current generated in a conductor by an EMF is proportional to the potential difference applied.

8. Under what possible diameter can a Tungsten wire have equal resistance to that of an equal length of Aluminum wire with diameter 3.84 mm? The resisivities for Tungsten and Aluminum wire are $5.25 \times 10^{-8}\,\Omega\,\mathrm{m}$ and $2.75 \times 10^{-8}\,\Omega\,\mathrm{m}$ respectively. **(3)**

Same calculation as the previous set.

Only name of the conductors and their parameters change.

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Quiz: 05, **Section**: 06/08

Date: April 30, 2024

Duration: 20 Minutes | **Spring 2024 (10F-29C)** | Marks: 15

Name: Student ID:

Use SI Units only. Partial Marks will be given for partially correct answers ONLY.

1. Kirchoff's Junction Rule works in a closed loop due to the conservation of — **(1)**

   ◯ Energy ◯ Charge ◯ Current ◯ Potential

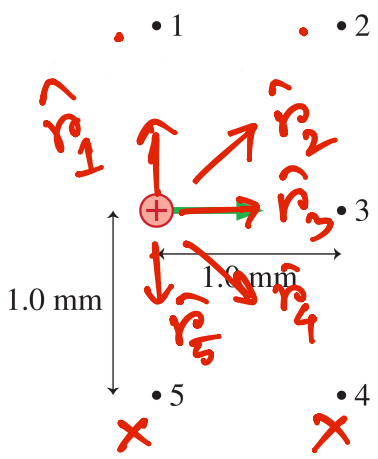
2. What makes a current loop behave like a bar magnet? — **(1)**

   ◯ Magnetic Dipole Moment ◯ Magnetic Field Intensity ◯ Electric Current ◯ Number of loop turns

3. What are the magnetic field vectors $\vec{B}_1$ through $\vec{B}_5$ at points 1 through 5 due to the moving charge? Use $\times$ or $\cdot$ notation to indicate a direction. Use the Biot-Savart only to find the direction. For that, Ddraw accurppropriate $\hat{r}$ vectors. vectors. Use $\times$ or $\cdot$ notation to indicate a direction. You do not have to calculate any values. Just an accurate drawing will do. **(4)**

Biot-Savart Law

$$\vec{B} = \frac{\mu_0}{4\pi} \frac{q\vec{v}\times\hat{r}}{r^2}.$$



(No field)

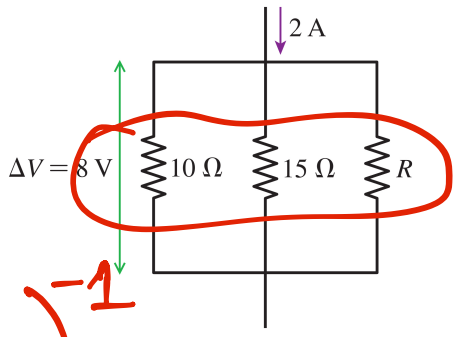
4. What is the short-circuit current of a 12 V car battery with an internal resistance of 0.020 Ω? How much power is lost/supplied by the battery? Can this power be supplied to the external circuit? **(3)**

$$I = \frac{\mathcal{E}}{R+r} \; ; \; \mathcal{E} = 12V, \; R = 0, \; r = 0.020\,\Omega.$$

$$P_{bat} = I^2 r.$$

$P_{ext} = 0$; since the circuit is shorted.

5. What is the value of resistor R? **(3)**



parallel

$$R_{eq} = \left(\frac{1}{10} + \frac{1}{15} + \frac{1}{R}\right)^{-1}$$

$$I = \frac{\Delta V}{R_{eq}}$$

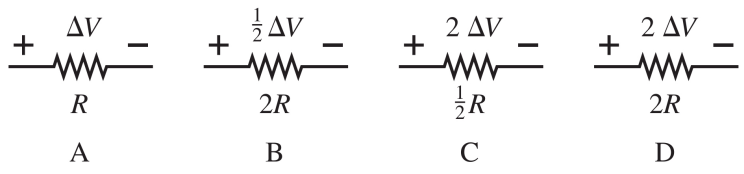
$$\Rightarrow 2A = 8V\left(\frac{1}{10} + \frac{1}{15} + \frac{1}{R}\right)\Omega$$

$$\Rightarrow 2A - \frac{8V}{10\Omega} - \frac{8V}{15\Omega} = \frac{8V}{R}$$

↳ from here, solve for R.

6. Rank in order, from smallest to largest, the powers P_A to P_D dissipated by resistor. **(3)**

$$P_R = \frac{\Delta V^2}{R}$$



$$P_A = \frac{\Delta V^2}{R}, \quad P_B = \frac{\left(\frac{1}{2}\Delta V\right)^2}{2R} = \frac{1}{4\times 2} \times \frac{\Delta V^2}{R} = \frac{1}{8} P_A.$$

$$P_C = \frac{(2\Delta V)^2}{\frac{1}{2}R} = 4\times 2 \times \frac{\Delta V^2}{R} = 8 P_A$$

$$P_D = \frac{(2\Delta V)^2}{2R} = \frac{4}{2} \times \frac{\Delta V^2}{R} = 2 P_A.$$

$P_B < P_A < P_D < P_C$

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Quiz: 04, **Section**: 06/08

Date: April 30, 2024

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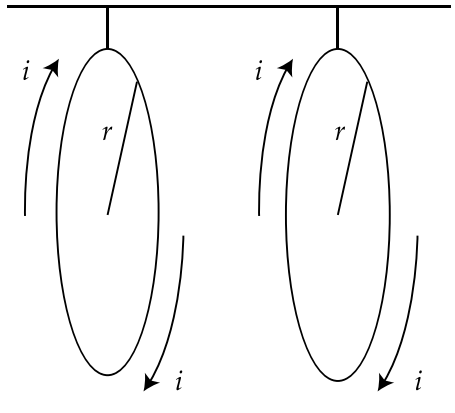
1. In what direction the net dipole moment due to these two current loop will point to? The loop is oriented in the $\hat{j}$ axis. — **(1)**



○ out of the page ◯ $-\hat{\imath}$ ○ $+\hat{\imath}$ ○ into the page

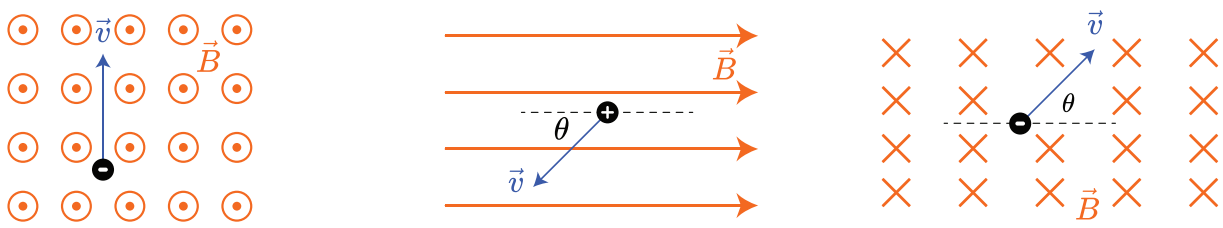
2. Reverse the current only in the left loop from Question-1. The two loops will — **(1)**

◯ repulse each other ○ attract each other ○ stay still ○ both sway rightward ○ both sway leftward

3. Reverse the current only in the right loop from Question-1. The two loops will — **(1)**

◯ repulse each other ○ attract each other ○ stay still ○ both sway rightward ○ both sway leftward

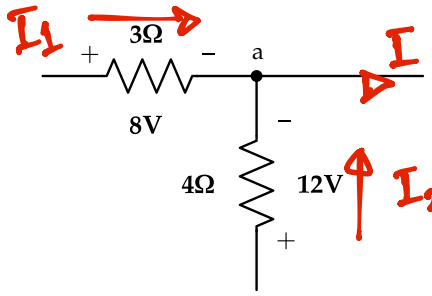
4. Take $v = 10^3\,\mathrm{m\,s^{-1}}$, $B = 1.5\,\mathrm{T}$, and $\theta = 30°$. Rank F_B experienced in an ascending order of magnitude (largest first). **(2)**



$\theta = 90°$ $\theta = 210°$ $\theta = 90°$

$F_B \propto |\sin\theta| \rightarrow F_A = F_C > F_B$ or $F_B < F_A = F_C$

5. Find the missing current at the junction a. Use KCL. Mention what sign convention You used. **(3)**



$I = I_1 + I_2$.

$= \frac{8V}{3\Omega} + \frac{12V}{4\Omega}$

$= +(\;)\,A$.

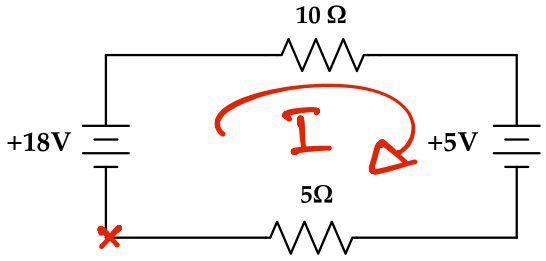
6. A 6 Ω flashlight bulb is powered by a 3 V battery with an internal resistance of 1 Ω. What are the power dissipation of the bulb and the terminal voltage of the battery? **(3)**

$$I = \frac{\mathcal{E}}{R+r} \quad ; \quad \mathcal{E} = 3V,\ R = 6\Omega,\ r = 1\Omega.$$

$$P_R = I^2 R.$$

$$(\Delta V)_{bat} = \mathcal{E} - Ir.$$

7. Find the voltage drop across the 5 Ω resistor and the direction of I in the circuit. Use only Kirchhoff's Loop rule to answer this. Mention travel directions and apply the sign convention accurately. **(4)**



clockwise travel

start/end

$$+18V - (10\Omega)I - 5V - (5\Omega)I = 0$$

$$\Rightarrow 13V - (15\Omega)I = 0$$

$$\Rightarrow I = \frac{13V}{15\Omega}\ ;\ \text{clockwise.}$$

$$(\Delta V)_{5\Omega} = I(5\Omega) = \frac{13V}{15\Omega} \times 5\Omega$$

$$= \frac{13}{3} V.$$