ÇANKAYA UNIVERSITY

Department of Mathematics and Computer Science

**PHYS 122 - General Physics II**

# SECOND MIDTERM EXAMINATION
21.04.2010

**STUDENT NUMBER:**

**NAME-SURNAME:**

**SIGNATURE:**

**INSTRUCTOR:** Emre Sermutlu

**DURATION:** 90 minutes

| Question | Grade | Out of |
|---|---|---|
| 1 | | 20 |
| 2 | | 20 |
| 3 | | 20 |
| 4 | | 20 |
| 5 | | 20 |
| Total | | 100 |

**IMPORTANT NOTES:**

**1)** Please make sure that you have written your student number and name above.

**2)** Check that the exam paper contains 5 problems.

**3)** Show all your work. No points will be given to correct answers without reasonable work.

Capacitor: $q = CV$

Capacitance of Parallel Plate Capacitor: $C = \dfrac{\varepsilon_0 A}{d}$

Capacitors in Parallel: $C_{eq} = \displaystyle\sum_{i=1}^{n} C_i$

Capacitors in Series: $\dfrac{1}{C_{eq}} = \displaystyle\sum_{i=1}^{n} \dfrac{1}{C_i}$

Energy Stored in a Capacitor: $U = \dfrac{1}{2}CV^2 = \dfrac{Q^2}{2C}$

Energy Density: $u = \dfrac{1}{2}\varepsilon_0 E^2$

Effect of Dielectric: $C = \kappa C_{air}$

Resistance of a Conductor: $R = \dfrac{V}{i}$

Resistance of a Wire of Length $L$, Cross-section $A$: $R = \rho\,\dfrac{L}{A}$

Power in Electrical Device: $P = iV$

Series Resistances: $R_{eq} = \displaystyle\sum_{j=1}^{n} R_j$

Parallel Resistances: $\dfrac{1}{R_{eq}} = \displaystyle\sum_{j=1}^{n} \dfrac{1}{R_j}$

Magnetic Force on a Moving Particle: $\vec{F}_B = q\overrightarrow{v} \times \overrightarrow{B}$

Charged Particle Circulating in a Magnetic Field: $r = \dfrac{mv}{|q|B}$

Magnetic Force on a Current - Carrying Wire: $\vec{F}_B = i\overrightarrow{L} \times \overrightarrow{B}$

Biot - Savart Law: $d\vec{B} = \dfrac{\mu_0}{4\pi}\dfrac{id\vec{s} \times \hat{r}}{r^2}$

Magnetic Field of a Long Straight Wire: $B = \dfrac{\mu_0 i}{2\pi R}$

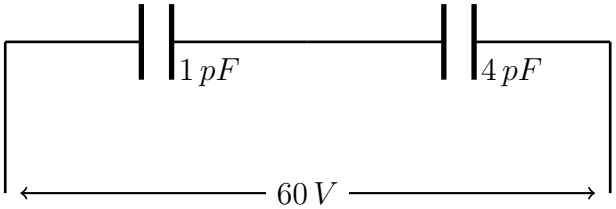
Magnetic Field of a Circular Arc (at center): $B = \dfrac{\mu_0 i\phi}{4\pi R}$

Force Between Parallel Currents: $F_{ba} = \dfrac{\mu_0 L i_a i_b}{2\pi d}$

Ampere's Law: $\displaystyle\oint \vec{B} \cdot d\vec{s} = \mu_0 i_{\text{enc}}$

**1) a)** A capacitor stores an energy of $1\mu\, j$ when the potential difference between its plates is $3\, V$. Find its capacitance.

**b)** Find the charge on the $4\, pF$ capacitor in the figure.




**Answer:**

**a)**

$$U = \frac{1}{2}CV^2$$

$$C = \frac{2U}{V^2} = \frac{12\mu j}{(3V)^2}$$

$$C = 0.22\mu F = 2.2. \times 10^{-7}\, F$$

**b)**

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{1}{1\, pF} + \frac{1}{4\, pF}$$

$$C_{eq} = 0.8\, pF$$

$$q = VC = 60V\, 0.8pF = 48\, pC$$

$$q_1 = q_2 = 4.8 \times 10^{-11}\, C$$

**2)** A cylindrical wire made of Nichrome has radius $r = 1\,mm$ and length $L$. Nichrome's resistivity is $\rho = 5 \times 10^{-7}\,\Omega \cdot m$. When a potential difference of $100\,V$ is applied, the power dissipation is $2000\,W$. Find $L$.

**Answer:**

$$P = \frac{V^2}{R} = \frac{(100V)^2}{2000W} = 5\,\Omega$$

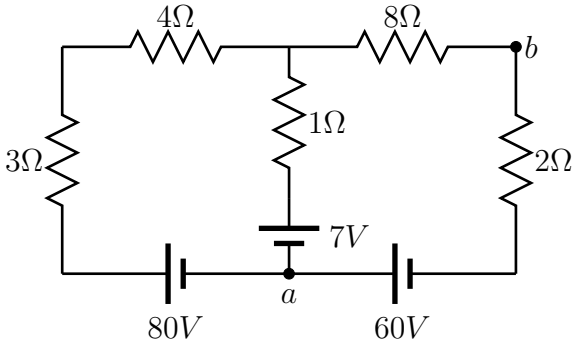
$$R = \frac{\rho L}{A} \quad \Rightarrow \quad L = \frac{AR}{\rho}$$

$$L = \frac{\pi(10^{-3}m)^2\,5\Omega}{5\,10^{-7}\,\Omega\,m} = 10\pi = 31.4\,m$$

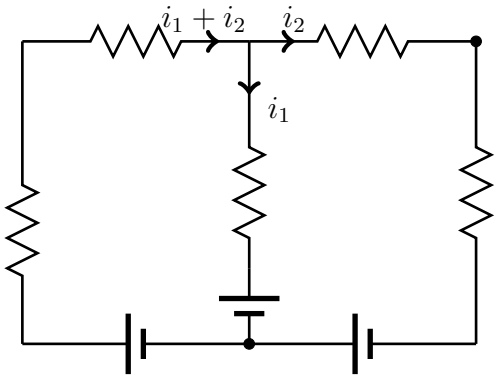
**3)** In the following circuit,

**a)** Find all currents

**b)** Find $V_{ab}$.




**Answer:**




$$\begin{aligned} 80 - 7(i_1 + i_2) - i_1 - 7 &= 0 \\ 7 + i_1 - 10i_2 + 60 &= 0 \end{aligned}$$

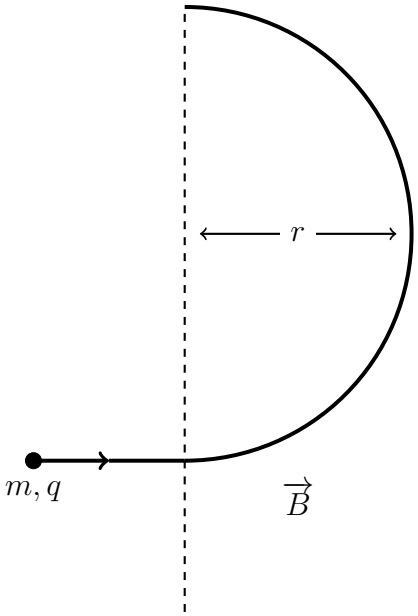
$$\begin{aligned} 8i_1 + 7i_2 &= 73 \\ -i_1 + 10i_2 &= 67 \end{aligned}$$

The solution of the system of equations give:

$$i_2 = 7\,A, \quad i_1 = 3\,A, \quad i_1 + i_2 = 10\,A$$

$$V_{ab} = +7 + 3 - 56 = -46V$$

**4)** A charged particle with mass $m$, charge $q$, kinetic energy $K$ enters a magnetic field and then follows a circle of radius $r$ as seen in the figure. Find the magnitude and direction of the magnetic field $\overrightarrow{B}$.




**Answer:**

$$K = \frac{1}{2}mv^2 \quad \Rightarrow \quad v = \sqrt{2K/m}$$

$$r = \frac{mv}{qB}$$

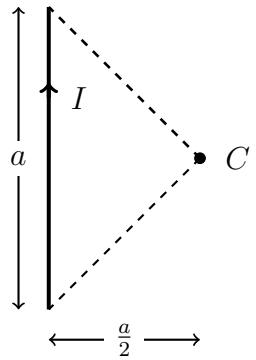
$$B = \frac{mv}{qr} = \frac{m\sqrt{2K/m}}{qr}$$

$$B = \frac{\sqrt{2Km}}{qr}$$

Using the right hand rule, we see that $\overrightarrow{B}$ is into the page.

**5)** A current of $I$ flows around a square of side length $a$. Find the magnitude of the magnetic field at the center of the square.

**Answer:**




Using Biot-Savart law for one side of the square, we obtain the magnetic field at $C$ as:

$$B = \int_{-\pi/4}^{\pi/4} \frac{\mu_0 I \cos\theta \, d\theta}{4\pi(a/2)}$$

$$B = \frac{\mu_0 I}{2\pi a} \sin\theta \Big|_{-\pi/4}^{\pi/4}$$

$$B = \frac{\mu_0 I \sqrt{2}}{2\pi a}$$

If we add the magnetic fields of all four sides:

$$B_{total} = 2\sqrt{2}\,\frac{\mu_0 I}{\pi a}$$