Kuwait University **Department of Physics**

General Physics II for Biological Sciences (Phy 122)

Second Midterm Examination (Summer Semester 2025-2026)

July 11, 2026
Time: 1:00 PM to **2:30 PM**

Instructor: Dr. S.S.A. Razee

Solution

Fundamental Constants

$k = 9 \times 10^{9}\ \mathrm{N \cdot m^2/C^2}$	Coulomb's constant
$\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{C^2/(N \cdot m^2)}$	Permitivity of free space
$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{T \cdot m/A}$	Permeability of free space
$e = 1.6 \times 10^{-19}\ \mathrm{C}$	Elementary charge
$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$	Mass of an electron
$m_p = 1.67 \times 10^{-27}\ \mathrm{kg}$	Mass of a proton
$\mathrm{eV} = 1.6 \times 10^{-19}\ \mathrm{J}$	Conversion from eV to J
$N_A = 6.022 \times 10^{23}/\mathrm{mol}$	Avogadro's number

Prefixes of units

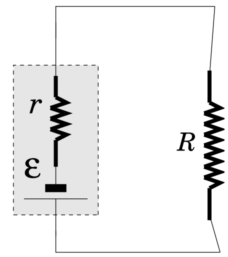
$\mathrm{m} = 10^{-3}$ $\mu = 10^{-6}$ $\mathrm{n} = 10^{-9}$ $\mathrm{p} = 10^{-12}$ $\mathrm{k} = 10^{3}$ $\mathrm{M} = 10^{6}$

Instructions to the Students:

- All communication devices must be switched off and placed in your bag. Anyone found using a communication device will be disqualified.
- Programmable calculators, which can store equations, are not allowed.

---

1. In the circuit shown, the emf of the real battery is $\mathcal{E} = 6.0$ V and its internal resistance is $r = 0.5\ \Omega$. The terminal voltage of the battery is $V_T = 5.8$ V. Find the power being dissipated in the unknown resistance R. **3 points**



Solution: We have

$$V_T = \mathcal{E} - Ir \implies I = \frac{\mathcal{E} - V_T}{r} = 0.4 \text{ A}$$

Since r and R are in series, the current is

$$I = \frac{\mathcal{E}}{R + r} \implies R = \frac{\mathcal{E}}{I} - r = 14.5\ \Omega$$

---

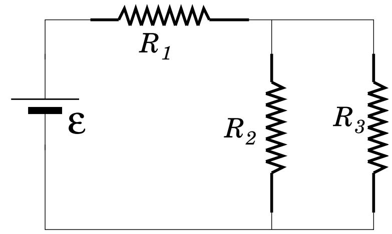
2. A wire of length $L = 20$ m and radius $a = 0.5$ mm is made of a material with resistivity $\rho = 6.0 \times 10^{-7}\ \Omega\cdot$m. Find the current in the wire when it is connected to a battery of emf $\mathcal{E} = 60.0$ V. **3 points**

Solution: We have

$$R = \rho\,\frac{L}{A} = \rho\,\frac{L}{\pi a^2} = 15.3\ \Omega$$

$$I = \frac{\mathcal{E}}{R} = 3.92 \text{ A}$$

3. An ideal battery of emf $\mathcal{E} = 30$ V is connected to three unknown reistors. The currents in R_1 and R_2 are respectively $I_1 = 2.0$ A and $I_2 = 1.2$ A. The power dissipated in R_3 is $P_3 = 9.6$ W. Find the power P_1 dissipated in R_1. **4 points**



Solution: We see that,

$$\left.\begin{array}{l} R_2 \text{ and } R_3 \text{ are parallel} \\ R_1 \text{ and } R_{23} \text{ are in series} \end{array}\right\} \implies I_1 = I_2 + I_3 \implies I_3 = I_1 - I_2 = 0.8\text{A}$$

Now
$$P_3 = I_3 V_3 \implies V_3 = \frac{P_3}{I_3} = 12 \text{ V}$$

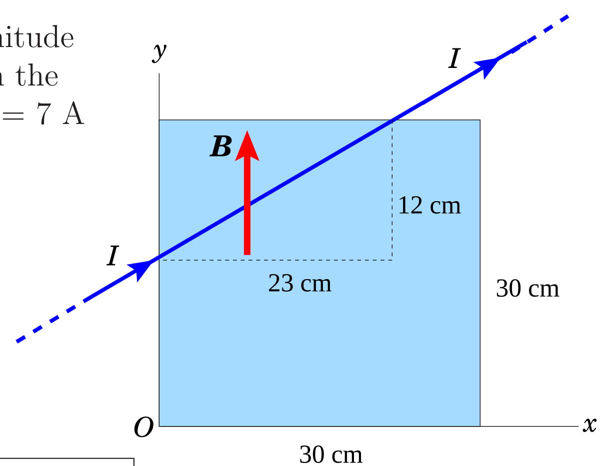
$$V_{23} = V_3 = 12 \text{ V}$$

$$V_1 = \mathcal{E} - V_{23} = 18 \text{ V}$$

$$P_1 = I_1 V_1 = 36 \text{ W}$$

---

4. We establish a uniform magnetic field of magnitude $B = 3.0 \times 10^{-3}$ T in **positive** $y-$**direction** in the shaded region. A straight wire with current $I = 7$ A passes through this region as shown.



(a) The direction of the magnetic force $\vec{F}_B$ on the wire is (Tick the correct answer). **1 point**

upward $\uparrow$ **downward** $\downarrow$

into-the-plane $\otimes$ **out-of-the-plane** $\odot$

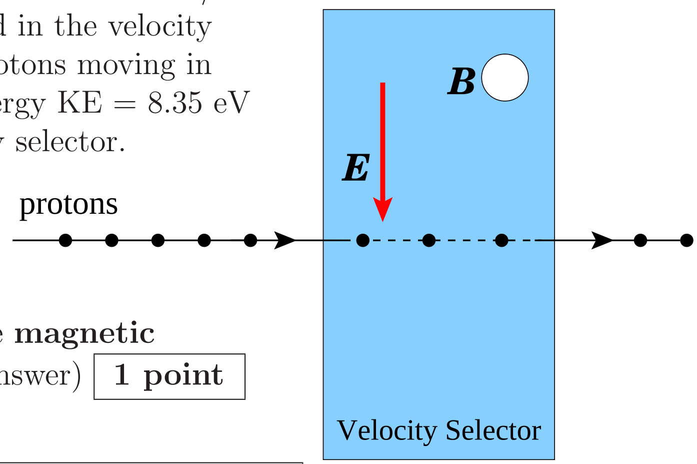
to-the-right $\longrightarrow$ **to-the-left** $\longleftarrow$

(b) Find the magnitude of the magnetic force (F_B) on the wire. **3 points**

We see that $L\ \sin\theta = 0.23$ m. So

$$F_B = ILB\ \sin\theta = IB \times 0.23 = 4.83 \times 10^{-3} \text{ N}$$

5. A uniform electric field of magnitude $E = 200$ N/C pointing **downward** is established in the velocity selector as shown. A stream of protons moving in the $+x-$direction with kinetic energy KE = 8.35 eV **pass straight throw** the velocity selector.



(a) What is the **direction** of the **magnetic field** $\vec{\boldsymbol{B}}$? (Tick the correct answer) **1 point**

into-the-plane $\otimes$ **out-of-the-plane** $\odot$

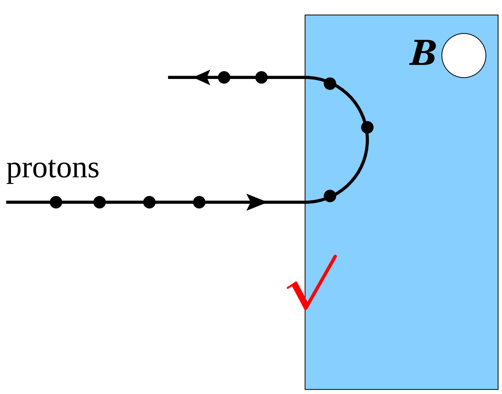
(b) Find the magnitude of the **magnetic field**. **2 points**

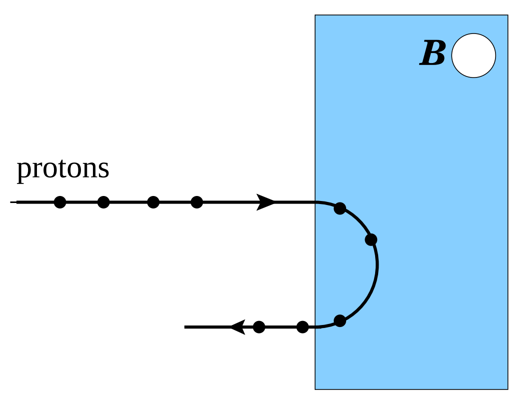
$$\text{KE} = 8.35 \text{ eV} = 1.336 \times 10^{-18} \text{ J}$$

$$v = \sqrt{\frac{2 \times \text{KE}}{m}} = 4.0 \times 10^{4} \text{ m/s}$$

$$B = \frac{E}{v} = 5.0 \times 10^{-3} \text{ T}$$

(c) If the **electric field is switched off**, the protons will move in circular paths. Which is the correct trajectory of protons? (Tick the correct figure). **1 point**

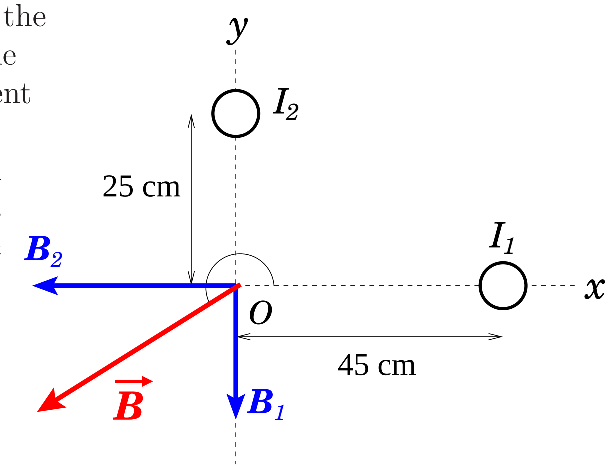




(d) Find the radius R of the circular path of the protons. **1 point**

$$R = \frac{mv}{Be} = 0.0835 \text{ m}$$

6. Two long straight wires are perpendicular to the $xy-$plane.The wire with current I_1 crosses the $x-$axis at $x = 45$ cm and the wire with current I_2 crosses the $y-$axis at $y = 25$ cm. The net magnetic field $\vec{\boldsymbol{B}}$ at the origin O makes an angle $\theta = 220^o$ with the positive $x-$axis as shown. The magnitude of the net magnetic field is $B = 8.0 \times 10^{-6}$ T.



(a) The current I_1 must be (Tick the correct answer). **1 point**

To get the $\boldsymbol{B}$ as given, $\boldsymbol{B}_1$ and $\boldsymbol{B}_2$ must be as shown. Then

into-the-plane $\otimes$ **out-of-the-plane** $\odot$ ✓

(b) The current I_2 must be (Tick the correct answer). **1 point**

into-the-plane $\otimes$ ✓ **out-of-the-plane** $\odot$

(c) Find the value of current I_1. **2 points**

$$B_1 = -B_y = -B \ \sin\theta = 5.14 \times 10^{-6} \text{ T}$$

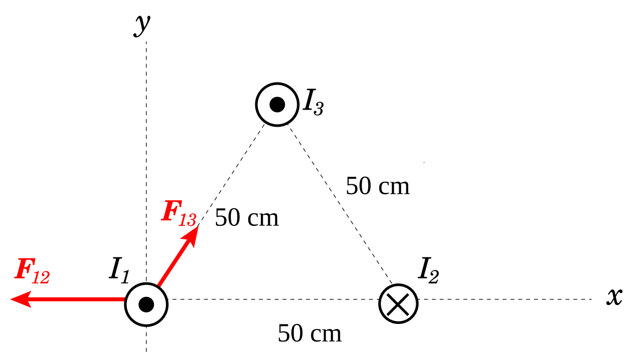
$$B_1 = \frac{\mu_0 I_1}{2\pi(0.45)} \implies I_1 = 11.6 \text{ A}$$

(d) Find the value of current I_2. **2 points**

$$B_2 = -B_x = -B \ \cos\theta = 6.13 \times 10^{-6} \text{ T}$$

$$B_2 = \frac{\mu_0 I_2}{2\pi(0.25)} \implies I_2 = 7.7 \text{ A}$$

7. Three long straight current-carrying wires are perpendicular to the $xy-$plane: **crossing the $xy-$plane at the corners of a equilateral triangle** of side 50 cm as shown. Given that $I_1 = 6$ A, $I_2 = 4$ A and $I_3 = 8$ A. The directions of the currents are shown in the figure.



$\dfrac{\vec{F}_1}{L}$ = **net magnetic force** per m of **wire 1**.

(a) Find $\dfrac{F_{1x}}{L}$. $\boxed{\textbf{3 points}}$

The forces $\dfrac{\vec{F}_{12}}{L}$ and $\dfrac{\vec{F}_{13}}{L}$ are shown.

$$\frac{F_{12}}{L} = \frac{\mu_0 I_1 I_2}{2\pi \times 0.5} = 9.6 \times 10^{-6} \text{ N/m}$$

$$\frac{F_{13}}{L} = \frac{\mu_0 I_1 I_3}{2\pi \times 0.5} = 1.92 \times 10^{-5} \text{ N/m}$$

So,

$$\frac{F_{1x}}{L} = \frac{F_{13}}{L} \cos 60^0 - \frac{F_{12}}{L} = 0$$

(b) Find $\dfrac{F_{1y}}{L}$. $\boxed{\textbf{3 points}}$

$$\frac{F_{1y}}{L} = \frac{F_{13}}{L} \sin 60^0 = 1.66 \times 10^{-5} \text{ N/m}$$