first (given) | last (family)

Name, *printed* as it appears in Canvas

Physics 2212 G

Spring 2019

Nine-digit Tech ID

Quiz

4A

- **Print** your name and nine-digit Tech ID *very neatly* in the spaces above.
- Free-response problems are numbered I–III. Show all your work clearly, including all steps and logic. Write **darkly**. Blue or black ink is recommended. Do not make any erasures in your free-response work. Cross out anything you do not want evaluated. Box your answer.
- Multiple-choice questions are numbered 1–7. For each, select the answer most nearly correct, circle it on your quiz, and fill the bubble for your answer on this front page.
- Initial the odd pages in the top margin, in case the pages of your quiz get separated.
- The standard formula sheet is on the back of this page, which may be removed from the quiz form if you wish, but it must be submitted.
- If the page for a free-response problem has insufficient space for your work, ask a proctor for an additional sheet. If you wish this work to be evaluated, put your name on the sheet and make a note on the problem page, so graders will know where to look for your work.
- You may use a calculator that cannot store letters, but no other aids or electronic devices.
- Your score will be posted when your quiz has been graded. Quiz grades become final after the first Reading Day, Wednesday, April 24.

Fill in bubbles for your Multiple Choice answers darkly and neatly.

	a	b	c	d	e
1	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
2	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
3	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
4	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
5	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
6	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
7	ⓐ	ⓑ	ⓒ	ⓓ	ⓔ
	a	b	c	d	e

Quiz and Exam Formulæ & Constants

$$k = \frac{1}{4\pi\epsilon_0}$$
$$\Delta V = -\int \vec{E}\cdot d\vec{s}$$
$$V = k\frac{q}{r}$$
$$\Delta U = q\,\Delta V$$
$$I = dq/dt$$
$$P = I\,\Delta V$$
$$R = \frac{\Delta V}{I}$$

Series :
$$\frac{1}{C_{\text{eq}}} = \sum \frac{1}{C_i}$$
$$R_{\text{eq}} = \sum R_i$$

Parallel :
$$\frac{1}{R_{\text{eq}}} = \sum \frac{1}{R_i}$$
$$C_{\text{eq}} = \sum C_i$$

$$\vec{E} = k\frac{q}{r^2}\hat{r}$$
$$\vec{F} = k\frac{q_1 q_2}{r^2}\hat{r}$$
$$\vec{F} = q\vec{E}$$
$$\vec{p} = q\vec{d}$$
$$\vec{\tau} = \vec{p}\times\vec{E}$$
$$U = -\vec{p}\cdot\vec{E}$$
$$|\vec{E}| \propto \frac{|\vec{p}|}{r^3}$$
$$\Phi_{\text{E}} = \int \vec{E}\cdot d\vec{A}$$
$$\epsilon_0 \oint \vec{E}\cdot d\vec{A} = q_{\text{enclosed}}$$
$$\oint \vec{E}\cdot d\vec{\ell} = -\frac{d\Phi_{\text{B}}}{dt}$$
$$C = \frac{Q}{\Delta V}$$
$$C = \epsilon_0\frac{A}{d}$$
$$U = \tfrac{1}{2}C\,[\Delta V]^2$$
$$R = \rho\frac{\ell}{A}$$
$$\tau_{\text{C}} = RC$$
$$u_{\text{E}} = \tfrac{1}{2}\epsilon_0 E^2$$

$$\vec{B} = \frac{\mu_0 q}{4\pi}\,\frac{\vec{v}\times\hat{r}}{r^2}$$
$$d\vec{B} = \frac{\mu_0 I}{4\pi}\,\frac{d\vec{\ell}\times\hat{r}}{r^2}$$
$$\vec{F} = q\vec{v}\times\vec{B}$$
$$\vec{F} = I\vec{\ell}\times\vec{B}$$
$$\vec{\mu} = NI\vec{A}$$
$$\vec{\tau} = \vec{\mu}\times\vec{B}$$
$$U = -\vec{\mu}\cdot\vec{B}$$
$$\Phi_{\text{B}} = \int \vec{B}\cdot d\vec{A}$$
$$\oint \vec{B}\cdot d\vec{A} = 0$$
$$\oint \vec{B}\cdot d\vec{\ell} = \mu_0(I_{\text{c}} + I_{\text{d}})$$
$$L = \frac{\Phi_{\text{B}}}{I}$$
$$L = \mu_0 N^2\frac{A}{\ell}$$
$$U = \tfrac{1}{2}LI^2$$
$$B = \mu_0 n I$$
$$\tau_{\text{L}} = L/R$$
$$u_{\text{B}} = \frac{1}{2\mu_0}B^2$$

$$q = q_{\max}\left(1 - e^{-t/\tau_{\text{C}}}\right)$$
$$q = q_0 e^{-t/\tau_{\text{C}}}$$
$$I = I_{\max}\left(1 - e^{-t/\tau_{\text{L}}}\right)$$
$$I = I_0 e^{-t/\tau_{\text{L}}}$$
$$I = \int \vec{J}\cdot d\vec{A}$$
$$\vec{J} = \sigma\vec{E}$$
$$\mathcal{E} = -N\frac{d\Phi_{\text{B}}}{dt}$$
$$I_d = \epsilon_0\,\frac{d\Phi_{\text{E}}}{dt}$$
$$\mathcal{E} = -L\,\frac{dI}{dt}$$
$$c = f\lambda = \frac{|\vec{E}|}{|\vec{B}|}$$
$$\vec{S} = \frac{1}{\mu_0}\,\vec{E}\times\vec{B}$$

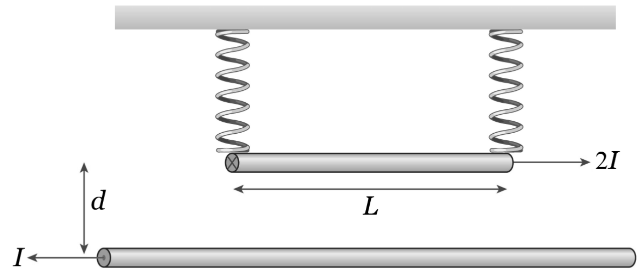
Fundamental Charge $e = 1.602\times10^{-19}\,\text{C}$
Earth's gravitational field $g = 9.81\,\text{N/kg}$
Coulomb constant $K = 8.988\times10^{9}\,\text{N}\cdot\text{m}^2/\text{C}^2$
Speed of Light $c = 2.998\times10^{8}\,\text{m/s}$

Mass of an Electron $m_{\text{e}} = 9.109\times10^{-31}\,\text{kg}$
Mass of a Proton $m_{\text{p}} = 1.673\times10^{-27}\,\text{kg}$
Vacuum Permittivity $\epsilon_0 = 8.854\times10^{-12}\,\text{C}^2/\text{N}\cdot\text{m}^2$
Vacuum Permeability $\mu_0 = 4\pi\times10^{-7}\,\text{T}\cdot\text{m/A}$

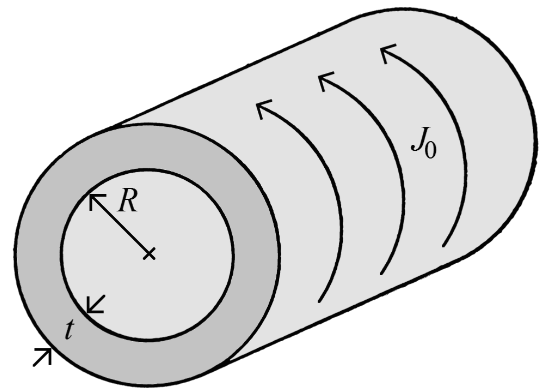
Unless otherwise directed, friction, drag, and gravity should be neglected, and all batteries and wires are ideal.
All derivatives and integrals in free-response problems must be evaluated.

You may remove this sheet from your Quiz or Exam

I. (16 points) A wire of length L is suspended horizontally by flexible leads above a long straight wire. Opposite currents I and $2I$ are established in the long and shorter wires, respectively, such that the shorter wire floats a distance d above the long wire with no tension in its suspension leads. If the mass of the shorter wire is m, what is the current I flowing in the long wire? Express your answer in terms of parameters defined in the problem, and physical or mathematical constants. (*On Earth, do NOT neglect gravity.*) **Note:** using a memorized formula for the force between two wires will incur a penalty for showing insufficient work.



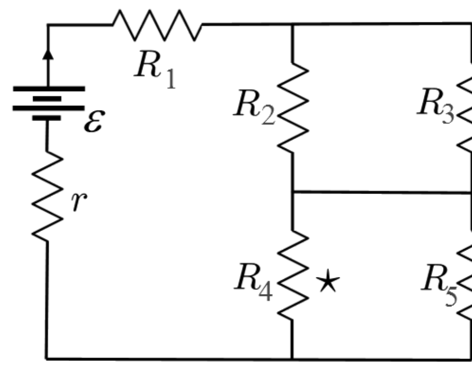
II. (16 points) Current flows counter-clockwise *around* an infinite hollow cylinder with inner radius R and thicknesses t, as shown. If the current density has a uniform magnitude J_0, what is the magnitude of the magnetic field in the center of the cylinder? Express your answer in terms of parameters defined in the problem, and physical or mathematical constants.



1. (6 points) In the problem above, what is the direction, if any, of the magnetic field in the center of the cylinder?

   (a) In to the page.
   (b) Out of the page.
   (c) Clockwise.
   (d) Counter-clockwise.
   (e) No direction, as the magnetic field magnitude must be zero in the center.

III. (16 points) The circuit shown consists of a battery of emf $\mathcal{E} = 24\,\mathrm{V}$ and internal resistance $r = 1.0\,\Omega$, and five identical resistors $R_1 \ldots R_5$, each with resistance $R = 8.0\,\Omega$. Calculate the current through the resistor R_4, indicated with a star.

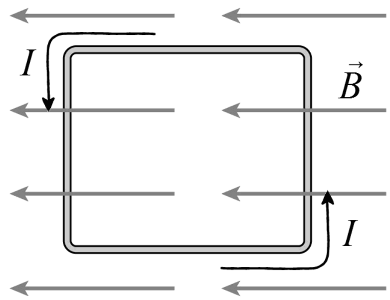


2. (6 points) In the problem above, how does the power P_4 dissipated in resistor R_4 compare to that dissipated by the internal resistance, P_r?

   (a) $P_4 = 2P_r$
   (b) $P_4 = P_r/2$
   (c) $P_4 = P_r/4$
   (d) $P_4 = 4P_r$
   (e) $P_4 = 8P_r$

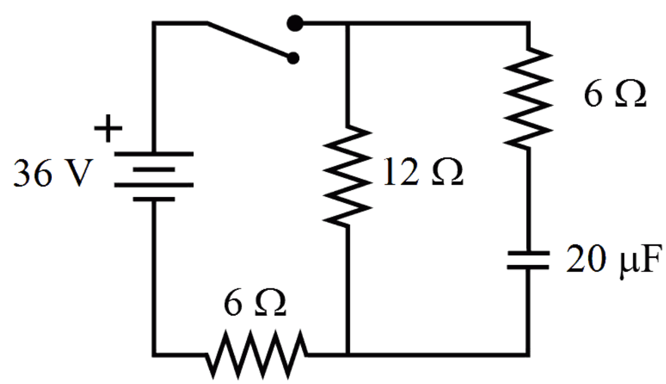
3. (8 points) A rectangular wire loop lies in the plane of the page with counter-clockwise current I. A uniform magnetic field $\vec{B}$ is directed to the left, as shown. What is the direction of the net torque, if any, on the loop?

(a) The net torque is up the page.
(b) The net torque is down the page.
(c) There is no net torque.
(d) The net torque is in to the page.
(e) The net torque is out of the page.



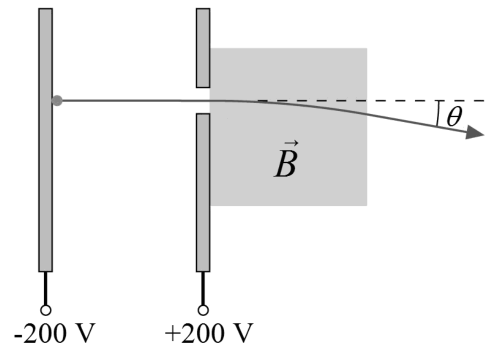
4. (8 points) A circuit is constructed with a 36 V battery, a switch, two 6 Ω resistors, a 12 Ω resistor, and a 20 μF capacitor, as shown. The switch has been closed for a long time. What is the current in the 12 Ω resistor immediately upon opening the switch?

(a) 1.0 A
(b) 1.5 A
(c) 1.3 A
(d) 2.0 A
(e) Zero A



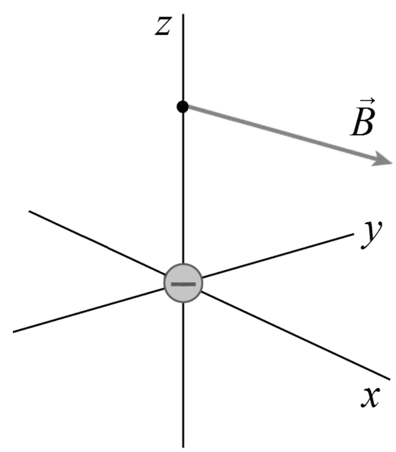
5. (8 points) The plates in a capacitor have the potentials indicated. A particle of unstated charge is released from rest at the -200 V plate and accelerates toward the +200 V plate. It passes through a small hole and enters a uniform magnetic field. If the particle's path is deflected down the page as shown, what is the direction of the magnetic field?

(a) Down the page.
(b) Into the page.
(c) Up the page.
(d) To the right.
(e) Out of the page.

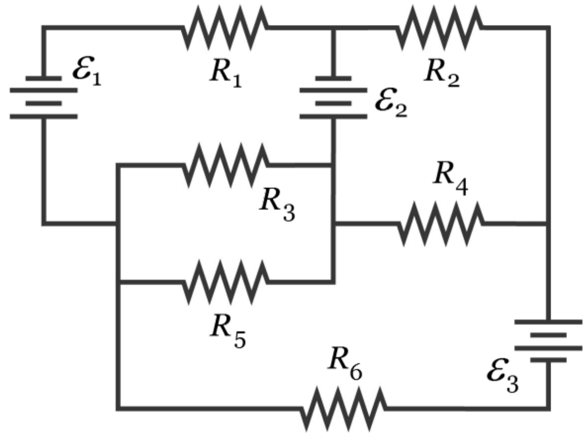


6. (8 points) As an electron passes through the origin, it generates a magnetic field on the $+z$ axis that points in the $+x$ direction, as shown. In what direction could this negatively-charged particle be traveling?

(a) In the $-x$ direction.
(b) In the $+x$ direction.
(c) In the $-y$ direction.
(d) In the $-z$ direction.
(e) In the $+y$ direction.



7. (8 points) In the illustrated circuit, current I_1 flows through resistor R_1, current I_2 flows through resistor R_2, etc. Let the positive direction of current flow be to the right through all the resistors. Which equation is a valid expression of Kirchhoff's Loop Law?



(a) $+\mathcal{E}_1 - I_6R_6 + \mathcal{E}_3 + I_2R_2 + \mathcal{E}_2 + I_3R_3 = 0$
(b) $+\mathcal{E}_1 - I_6R_6 + \mathcal{E}_3 - I_4R_4 - \mathcal{E}_2 - I_1R_1 = 0$
(c) $+\mathcal{E}_1 - I_6R_6 + \mathcal{E}_3 + I_4R_4 - \mathcal{E}_2 + I_1R_1 = 0$
(d) $+\mathcal{E}_1 - I_6R_6 + \mathcal{E}_3 - I_2R_2 + \mathcal{E}_2 - I_3R_3 = 0$
(e) $+\mathcal{E}_1 - I_6R_6 + \mathcal{E}_3 + I_2R_2 + \mathcal{E}_2 + I_5R_5 = 0$