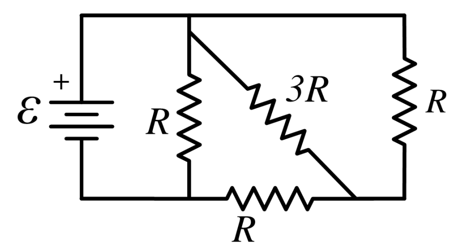
Version Quiz #4 Form #425 Name:__________

A

Physics 2212 G Spring 2018 Recitation Section:__________

- Print your name, quiz form number (3 digits at the top of this form), and student number (9 digit Georgia Tech ID number) in the section of the answer card labeled "Student Identification."
- Bubble the Quiz Form Number in columns 1–3, skip column 4, then bubble your Student Number in columns 5–13.
- Free-response questions are numbered I–III. For each, make no marks and leave no space on your card. Show all your work clearly, including all steps and logic. Box your answer.
- Multiple-choice questions are numbered 1–7. For each, select the answer most nearly correct, circle this answer on your quiz, and bubble it on your answer card. Do not put any extra marks on the card.
- Turn in your quiz and answer card as you leave. Your score will be posted when your quiz has been graded. Quiz grades become final when the next quiz is given.
- You may use a calculator that cannot store letters, but no other aids or electronic devices.

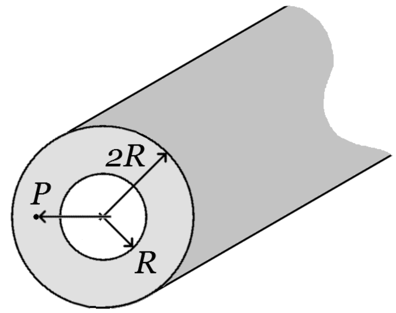
I. (16 points) The circuit shown has an emf $\mathcal{E}$, three resistors with resistance R, and one resistor with resistance $3R$. What is the current through the resistor with resistance $3R$? Express your answer in terms of parameters defined in the problem, and physical or mathematical constants.



II. (16 points) An infinite straight hollow wire has inner radius R and outer radius $2R$, as illustrated. Its current density, $\vec{J}$, is directed into the page and has a magnitude that varies with distance r from the center according to

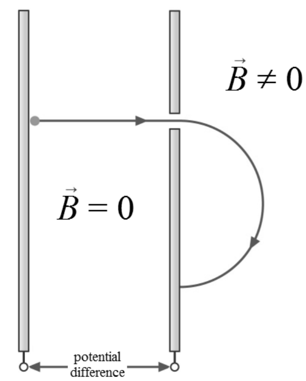
$$J = J_0 \frac{R^2}{r^2}$$

where J_0 is a positive constant. Find the magnetic field magnitude at a point P which is a distance $3R/2$ from the center, in terms of parameters defined in the problem, and physical or mathematical constants.



1. (6 points) In the problem above, what is the direction of the magnetic field at the illustrated point P?
   (a) To the right (toward the center).
   (b) Up the page.
   (c) Down the page.
   (d) To the left (away from the center).
   (e) There is no direction, as the magnetic field magnitude is zero.

2. (6 points) A positively-charged particle is accelerated from rest through a potential difference, then passes through a region of uniform magnetic field with magnitude B. It follows a half-circle, as illustrated, and strikes the plate defining the edge of the field.

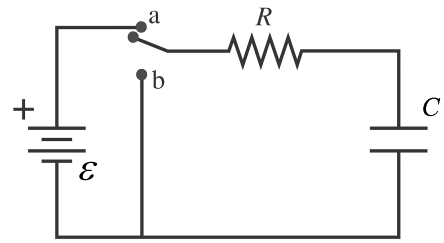


What is the direction of the magnetic field?

(a) In to the page.
(b) Down the page.
(c) Out of the page.
(d) Toward the left.
(e) Up the page.

III. (16 points) The particle in the problem above has mass m, charge magnitude q, and enters the magnetic field with speed v. At what time Δt after entering the field does the particle strike the plate? Express your answer in terms of parameters defined in the problem, and physical or mathematical constants

3. (8 points) The switch in the illustrated circuit is set to position "b" for a long time, then set to position "a" for a time t_a, then set back to position "b". After that, the current through the resistor is



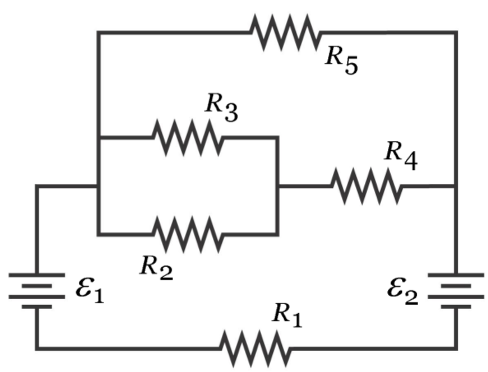
$$I = I_0 e^{-t_b/RC}$$

where t_b is the time from returning the switch to position "b". What is I_0?

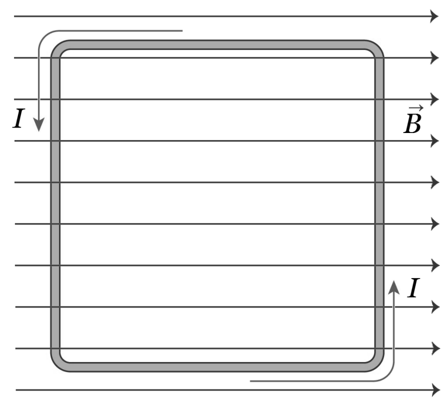
(a) 0
(b) $\mathcal{E}/R$
(c) $(\mathcal{E}/R)\left(1 - e^{-t_a/RC}\right)$
(d) $(\mathcal{E}/R)\, e^{-t_a/RC}$

4. (8 points) Resistors R_1 through R_5 in the illustrated circuit carry currents I_1 through I_5, respectively. Let the positive direction of current flow be left to right through all the resistors. Which equation is a valid expression of Kirchhoff's Loop Law?

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



5. (8 points) A square wire loop lies in the plane of the page, carrying a counterclockwise current. A uniform magnetic field is directed to the right, as illustrated. What effect does the net torque, if any, have on the loop?



(a) The net torque lifts the right side of the loop out of the page.
(b) The net torque rotates the loop counterclockwise.
(c) The net torque lifts the top of the loop out of the page.
(d) The net torque lifts the left side of the loop out of the page.
(e) There is no effect, as the net torque is zero.

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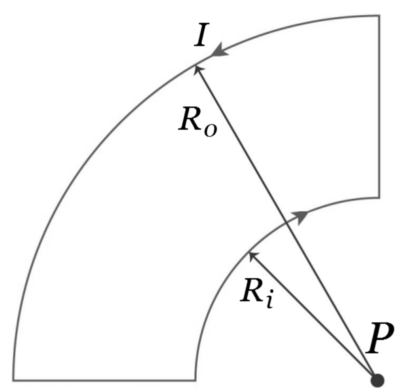
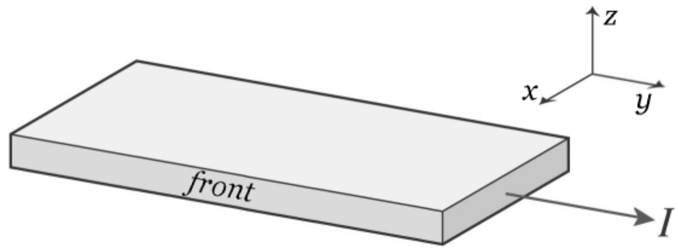
6. (8 points) A current I flows counterclockwise around a loop constructed of two quarter-circle arcs joined as shown. The inner arc has radius R_i and the outer arc has radius R_o. What is the direction of the magnetic field at point P, the center of the arcs?



(a) To the right.
(b) Into the page.
(c) Up the page.
(d) Out of the page.
(e) No direction, as magnitude is zero.

7. (8 points) The illustrated slab is metal, so the charge carriers are electrons. It lies in a uniform magnetic field and *conventional current* flows through it to the right (in the $+y$ direction). The visible front face is at lower electric potential than the hidden back face. In what direction does the magnetic field point?

   (a) $+x$
   (b) The situation described is impossible.
   (c) $-x$
   (d) $-z$
   (e) $+z$



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 :

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

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

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

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

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

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

Please remove this sheet from your Quiz or Exam

Version: A