

$$k = \frac{1}{4\pi\epsilon_0}$$

$$\Delta V = - \int \vec{E} \cdot d\vec{s}$$

$$V = k \frac{q}{r}$$

$$\Delta U = q \Delta V$$

$$I = dq/dt$$

$$P = I \Delta V$$

$$R = \frac{\Delta V}{I}$$

Series :

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

$$R_{\text{eq}} = \sum R_i$$

Parallel :

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

$$C_{\text{eq}} = \sum C_i$$

$$\vec{E} = k \frac{q}{r^2} \hat{r}$$

$$\vec{F} = k \frac{q_1 q_2}{r^2} \hat{r}$$

$$\vec{F} = q \vec{E}$$

$$\vec{p} = q \vec{d}$$

$$\vec{\tau} = \vec{p} \times \vec{E}$$

$$U = -\vec{p} \cdot \vec{E}$$

$$|\vec{E}| \propto \frac{|\vec{p}|}{r^3}$$

$$\Phi_E = \int \vec{E} \cdot d\vec{A}$$

$$\epsilon_0 \oint \vec{E} \cdot d\vec{A} = q_{\text{enclosed}}$$

$$\oint \vec{E} \cdot d\vec{\ell} = -\frac{d\Phi_E}{dt}$$

$$C = \frac{Q}{\Delta V}$$

$$C = \epsilon_0 \frac{A}{d}$$

$$U = \frac{1}{2} C [\Delta V]^2$$

$$R = \rho \frac{\ell}{A}$$

$$\tau_C = RC$$

$$u_E = \frac{1}{2} \epsilon_0 E^2$$

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

$$d\vec{B} = \frac{\mu_0 I}{4\pi} \frac{d\vec{\ell} \times \hat{r}}{r^2}$$

$$\vec{F} = q \vec{v} \times \vec{B}$$

$$\vec{F} = I \vec{\ell} \times \vec{B}$$

$$\vec{\mu} = NI \vec{A}$$

$$\vec{\tau} = \vec{\mu} \times \vec{B}$$

$$U = -\vec{\mu} \cdot \vec{B}$$

$$\Phi_B = \int \vec{B} \cdot d\vec{A}$$

$$\oint \vec{B} \cdot d\vec{A} = 0$$

$$\oint \vec{B} \cdot d\vec{\ell} = \mu_0 (I_c + I_d)$$

$$L = \frac{\Phi_B}{I}$$

$$L = \mu_0 N^2 \frac{A}{\ell}$$

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

$$B = \mu_0 n I$$

$$\tau_L = L/R$$

$$u_B = \frac{1}{2\mu_0} B^2$$

$$q = q_{\text{max}} \left(1 - e^{-t/\tau_c} \right)$$

$$q = q_0 e^{-t/\tau_c}$$

$$I = I_{\text{max}} \left(1 - e^{-t/\tau_L} \right)$$

$$I = I_0 e^{-t/\tau_L}$$

$$I = \int \vec{J} \cdot d\vec{A}$$

$$\vec{J} = \sigma \vec{E}$$

$$\mathcal{E} = -N \frac{d\Phi_B}{dt}$$

$$I_d = \epsilon_0 \frac{d\Phi_E}{dt}$$

$$\mathcal{E} = -L \frac{dI}{dt}$$

$$c = f\lambda = \frac{|\vec{E}|}{|\vec{B}|}$$

$$\vec{S} = \frac{1}{\mu_0} \vec{E} \times \vec{B}$$

Fundamental Charge $e = 1.602 \times 10^{-19} \text{ C}$
 Earth's gravitational field $g = 9.81 \text{ N/kg}$
 Coulomb constant $K = 8.988 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2$
 Speed of Light $c = 2.998 \times 10^8 \text{ m/s}$

Mass of an Electron $m_e = 9.109 \times 10^{-31} \text{ kg}$
 Mass of a Proton $m_p = 1.673 \times 10^{-27} \text{ kg}$
 Vacuum Permittivity $\epsilon_0 = 8.854 \times 10^{-12} \text{ C}^2/\text{N}\cdot\text{m}^2$
 Vacuum Permeability $\mu_0 = 4\pi \times 10^{-7} \text{ T}\cdot\text{m/A}$

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.

STUDENT IDENTIFICATION

George P. Burdell

123 900987654

WRITTEN information for human benefit

Test Form Number from YOUR test

column 4 is blank

YOUR student number starts in column 5

26

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

— Your answers

SCN-151-10

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YOUR form number is **241**

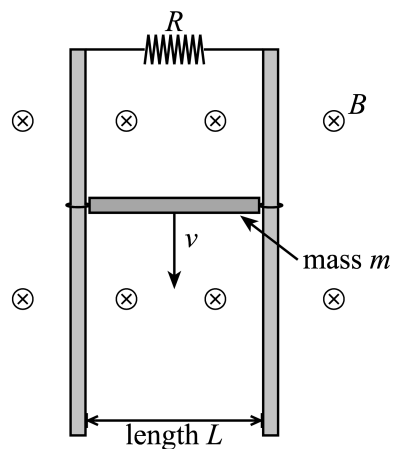
Recitation Sections

	Clough 123	Clough 127	Clough 131	Clough 325	Clough 423
WEDNESDAY					
1:05 pm				G01 Chang, Patrick Note: Meets in 323	
2:05 pm					G06/H01 Daum, Marcus
3:05 pm			G05/H05 Daum, Marcus		
4:05 pm		G02 Daum, Marcus		H02 Chang, Patrick	
5:05 pm	G09 Chang, Patrick	H06/H09 Daum, Marcus			
THURSDAY					
12:05 pm		H07 Daum, Marcus			
1:05 pm					
2:05 pm					
3:05 pm			G03 Daum, Marcus	G07 Chang, Patrick	H03 Tao, Liangyu
4:05 pm				G04 Chang, Patrick	
5:05 pm		G08 Tao, Liangyu		H04/H08 Chang, Patrick	

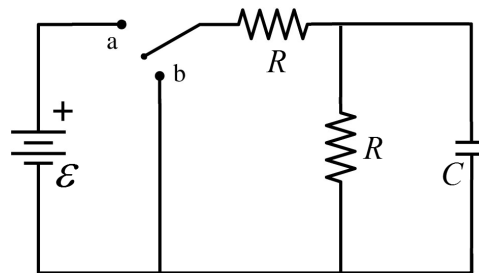
A

- 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 1–10. 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. (18 points) A bar (mass m , length L) is connected to two frictionless vertical conducting rails with loops of wire, in the presence of a uniform magnetic field $\vec{B}$. The tops of the rails are connected through a resistor R . When released from rest, the bar slides down the rails, accelerating more and more slowly until it reaches a constant terminal speed v . Find an expression for v in terms of parameters defined in the problem and physical or mathematical constants. (*On Earth. Do NOT neglect gravity.*)

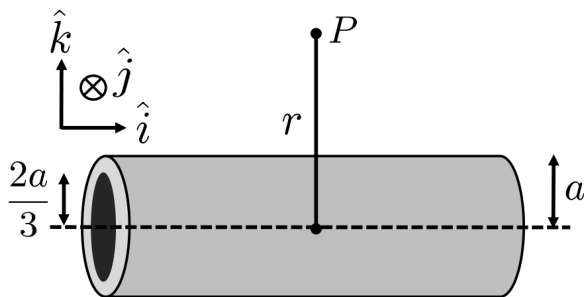


- II. (16 points) In the circuit shown, $\mathcal{E} = 9.0\text{ V}$, $R = 100.0\ \Omega$ and $C = 20.0\ \mu\text{F}$. The switch has been in position “a” for a long time, then is thrown to position “b”. What is the current from the capacitor 1.8 ms after the switch is thrown?



- (5 points) At the instant the switch is thrown to “b” in the problem above, let the current from the capacitor be I_0 and the potential energy stored in the capacitor be U_0 , with respect to zero in the uncharged state. When the current from the capacitor has decreased to half its initial value ($I = I_0/2$), what potential energy is stored in the capacitor?
 - $U = 2U_0/\sqrt{2}$
 - $U = U_0/2$
 - $U = 3U_0/4$
 - $U = U_0/\sqrt{2}$
 - $U = U_0/4$

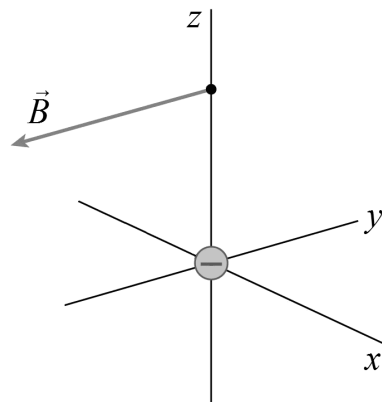
- III. (16 points) An infinitely long hollow wire has inner radius $2a/3$ and outer radius a . A uniform current density $\vec{J}_0$ flows in the $\hat{i}$ direction in the conductor. No current flows in the hollow. What is the magnitude of the magnetic field created at a point P located at a distance $r > a$ from the axis of the wire? Express your answer in terms of parameters defined in the problem and physical or mathematical constants.



2. (5 points) Assuming $J_0 > 0$ in the problem above, what is the direction of the magnetic field at the point P ?
- (a) $-\hat{j}$
 - (b) $+\hat{j}$
 - (c) $+\hat{k}$
 - (d) $-\hat{k}$
 - (e) $+\hat{i}$

-
3. (5 points) As a particle with a charge of -1.0 nC passes through the origin, it generates a magnetic field on the $+z$ axis that points in the $-y$ direction, as shown. In what direction could this negatively-charged particle be traveling?

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

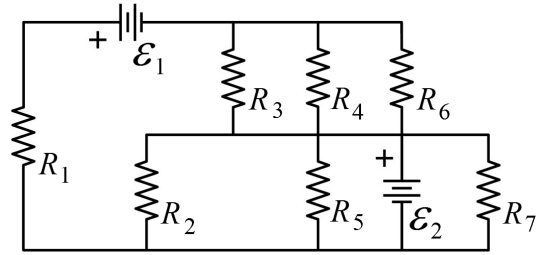


4. (5 points) In the problem above, the magnetic field has a magnitude of 2.5 nT at a position $z = +9.8\text{ cm}$ as the particle passes through the origin. What is the minimum speed of the particle?

- (a) $2.4 \times 10^5\text{ m/s}$
- (b) $3.6 \times 10^9\text{ m/s}$
- (c) $1.5 \times 10^7\text{ m/s}$
- (d) $8.3 \times 10^7\text{ m/s}$
- (e) $2.0 \times 10^6\text{ m/s}$

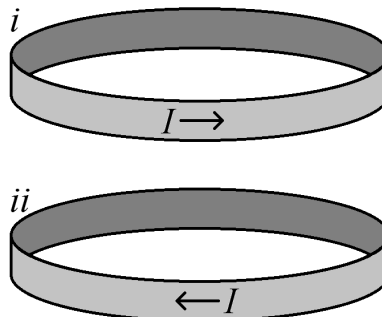
5. (5 points) Let the positive direction of current flow be up the page in the circuit shown. The current I_1 flows through resistor R_1 , etc. Which is a valid expression of Kirchhoff's Loop Law?

- (a) $+\mathcal{E}_1 + I_1 R_1 - \mathcal{E}_2 + I_6 R_6 = 0$
 (b) $+\mathcal{E}_1 + I_1 R_1 + \mathcal{E}_2 - I_4 R_4 = 0$
 (c) $+\mathcal{E}_1 - I_1 R_1 - I_2 R_2 - I_3 R_3 = 0$
 (d) $+\mathcal{E}_1 - I_1 R_1 - I_5 R_5 + I_7 R_7 = 0$
 (e) $+\mathcal{E}_1 + I_1 R_1 - I_2 R_2 - \mathcal{E}_2 = 0$



6. (5 points) Identical conducting rings, i and ii , carry currents I of identical magnitude, but that travel in opposite senses, as shown. What is the direction of the magnetic force, if any, on each ring?

- (a) The force on ring i is down the page, but the force on ring ii is up the page.
 (b) The force on ring i is down the page, and the force on ring ii is down the page.
 (c) The force on ring i is up the page, but the force on ring ii is down the page.
 (d) There is no net magnetic force on ring i , and there is no net magnetic force on ring ii .
 (e) The force on ring i is up the page, and the force on ring ii is up the page.

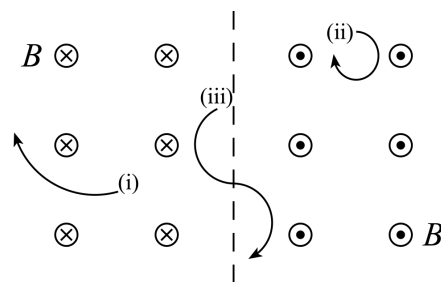


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7. (5 points) A long wire of length L and width (or diameter) w is to be used to make a solenoid. The entire wire will be wrapped in a single layer, with adjacent coils touching (that is, packed as closely together as possible without overlapping). A known, fixed current I will flow through the wire, making a magnetic field inside the solenoid. You may assume that the resulting solenoid is much longer than its diameter. What is the magnitude of the magnetic field inside the solenoid?

- (a) $B = \mu_0 I w / L^2$
- (b) $B = \mu_0 I / L$
- (c) $B = \mu_0 I / (\pi L)$
- (d) $B = \mu_0 I / w$
- (e) $B = \mu_0 I L / w^2$

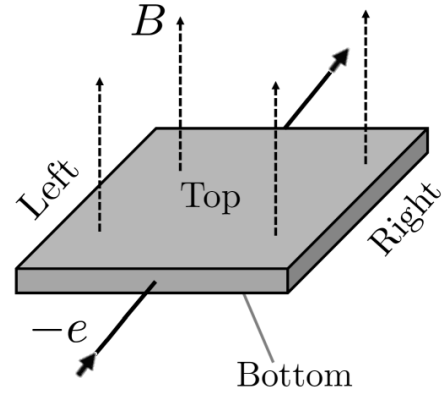
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8. (5 points) The accompanying figure shows the tracks of several charged particles in the presence of magnetic fields. The magnetic field is uniform and into the page on the left; it is uniform and out of the page on the right. Which of these particles is positively charged, and which negatively?

- (a) (i) is negative; (ii) is positive; (iii) is impossible.
- (b) (i) is positive; (ii) is positive; (iii) is negative.
- (c) (i) is negative; (ii) is positive; (iii) is positive.
- (d) (i) is negative; (ii) is negative; (iii) is positive.
- (e) (i) is positive; (ii) is negative; (iii) is negative.



9. (5 points) Electrons are injected in a sheet of conducting material immersed in a uniform magnetic field B as shown. Electrons are deflected ...

- (a) and a difference of potential is created between the left and right faces with $V_R - V_L > 0$.
- (b) and a difference of potential is created between the top and bottom faces with $V_B - V_T < 0$.
- (c) but no difference of potential is created.
- (d) and a difference of potential is created between the left and right faces with $V_R - V_L < 0$.
- (e) and a difference of potential is created between the top and bottom faces with $V_B - V_T > 0$.



10. (5 points) A infinitely long thin wire and a current loop of radius R lie in the same plane and are touching as shown. A current I flows in the wire and in the loop in the directions indicated on the drawing. What is the magnitude of the magnetic field at point P ?

- (a) $\frac{\mu_0 I}{2R} \frac{1-\pi}{\pi}$
- (b) $\frac{\mu_0 I}{2R} \frac{\pi}{1-\pi}$
- (c) $\frac{\mu_0 I}{2R} \frac{1+\pi}{\pi}$
- (d) $\frac{\mu_0 I}{2R} \frac{1+\pi}{4\pi}$
- (e) $\frac{\mu_0 I}{2R} \frac{\pi}{1+\pi}$

