first (given)	last (family)

Name, *printed* as it appears in Canvas

Physics 2212 G

Spring 2022

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 1–8. 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 last class meeting, Monday, April 25.

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

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

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

Parallel :

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

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

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

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

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

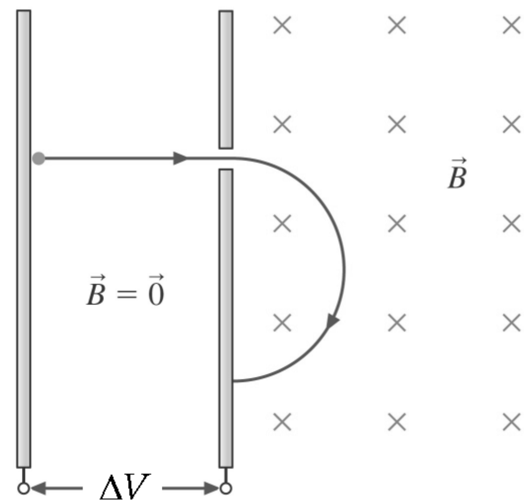
Mass of an Electron $m_{\rm e} = 9.109\times10^{-31}\,\rm kg$
Mass of a Proton $m_{\rm p} = 1.673\times10^{-27}\,\rm kg$
Vacuum Permittivity $\epsilon_0 = 8.854\times10^{-12}\,\rm C^2/N\cdot m^2$
Vacuum Permeability $\mu_0 = 4\pi\times10^{-7}\,\rm T\cdot m/A$

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

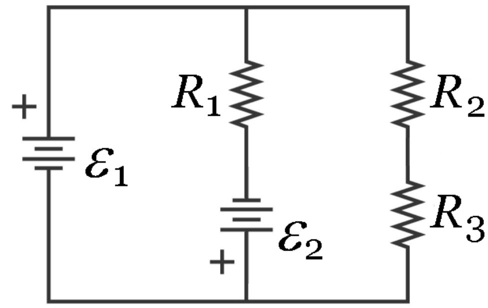
You may remove this sheet from your Quiz or Exam

I. (16 points)A particle is accelerated from rest through a potential difference, then passes through a region of uniform magnetic field with magnitude B, which is directed into the page. It follows a half-circle, as illustrated, and strikes the plate defining the edge of the field.

If the particle has mass m and charge magnitude q, 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.



II. (16 points) In the illustrated electric circuit, $\mathcal{E}_1 = 9.0\,\text{V}$, $\mathcal{E}_2 = 12\,\text{V}$, $R_1 = 11\,\Omega$, $R_2 = 22\,\Omega$, and $R_3 = 33\,\Omega$. What power is dissipated in the resistor R_2?



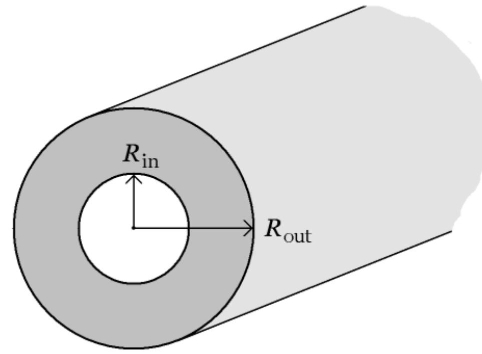
1. (6 points) In the problem above, let the power dissipated in resistor R_2 be P_2. If the emf of both batteries were *doubled*, what new power P_2' would be dissipated in resistor R_2?

   (a) $P_2' = 2P_2$
   (b) $P_2' = 4P_2$
   (c) $P_2' = P_2/4$
   (d) $P_2' = P_2$
   (e) $P_2' = P_2/2$

III. (16 points)A hollow cylindrical conductor has inner radius R_{in} and outer radius R_{out}. It carries a current out of the page whose density, $\vec{J}$, has magnitude

$$|\vec{J}| = J_0\left(\frac{R_{\text{in}}R_{\text{out}}}{r^2}\right)$$

where r is the distance from the cylinder axis and J_0 is a constant. What is the magnitude of the magnetic field at a distance R' from the cylinder axis, where $R_{\text{in}} < R' < R_{\text{out}}$? Express your answer in terms of parameters defined in the problem, and physical or mathematical constants.

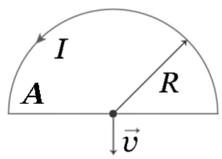


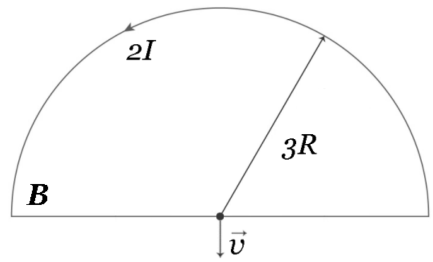
2. (6 points) Let your answer to the problem above be B'. What is the magnitude of the magnetic field at a distance $R'' = R_{\text{in}}/2$ from the cylinder axis?

   (a) $2B'$
   (b) $B'/4$
   (c) $4B'$
   (d) Zero
   (e) $B'/2$

3. (7 points) The wires shown below are bent into semicircles, connected by a straight wire between their ends. Wire A is on the left and wire B is on the right, and the two wires are far apart. An electron is located at the center of each circle (but outside the wires), moving with velocity $\vec{v}$ in the direction perpendicular to the straight connecting lines, as shown. Compare the magnitude of the force F_B on the electron at the center of wire B, to the magnitude of the force F_A on the electron at the center of wire A.

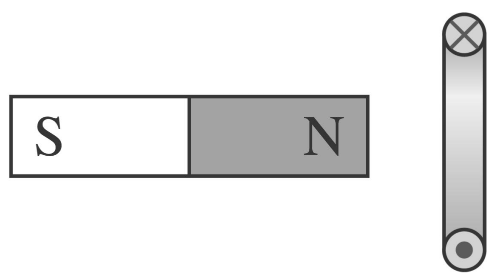
(a) $F_B = 2F_A/3$
(b) $F_B = 3F_A/2$
(c) $F_B = 4F_A/3$
(d) $F_B = 2F_A/9$
(e) $F_B = 9F_A/4$



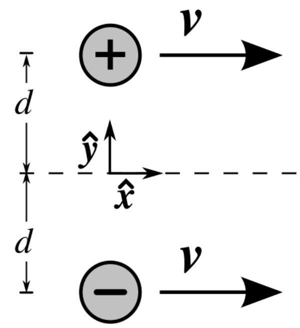


4. (7 points) The current loop in the figure is shown in cross-section, with current flowing into the page at the top, and out at the bottom. A permanent magnet is to the left of the loop, with the north end nearest the loop. If there is a force on the loop from the magnet, what is its direction?

(a) There is a force on the loop into the page.
(b) There is no force on the loop.
(c) There is a force on the loop to the left.
(d) There is a force on the loop out of the page.
(e) There is a force on the loop to the right.



5. (7 points) A charge $+q_0 > 0$ moves with velocity $\vec{v} = v\hat{x}$ along a line $y = +d, z = 0$. A second charge $-q_0$ travels with identical velocity $\vec{v}$ along a line $y = -d, z = 0$. The two charges pass the origin at the same instant. When the charges pass the origin, which of the following expressions best describes the magnetic field at the origin?



(a) $+\frac{\mu_0}{2\pi}\frac{q_0 v}{d^2}\hat{z}$ (out of the page)
(b) $-\frac{\mu_0}{2\pi}\frac{q_0 v}{d^2}\hat{z}$ (into the page)
(c) The magnetic field is zero, so it has no direction.
(d) $-\frac{\mu_0}{2\pi}\frac{q_0 v}{d^2}\hat{y}$ (down the page)
(e) $+\frac{\mu_0}{2\pi}\frac{q_0 v}{d^2}\hat{y}$ (up the page)

6. (7 points) A long straight wire carries a current out of the page, as illustrated on the near-right. The small current loop, shown in cross-section on the far-right, carries a current into the page at the top and out of the page at the bottom. The loop is free to rotate, but not to translate. What is the equilibrium orientation, if any, of the loop?

(a)

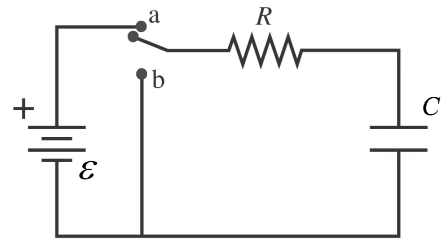

(b)


(c)


(d)


(e) The loop has no equilibrium orientation.

7. (6 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 charge on the capacitor is



$$Q = Q_0 e^{-t_b/RC}$$

where t_b is the time from returning the switch to position "b". What is Q_0?

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

8. (6 points) In the problem above, after the switch is set back to position "b", 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) $(\mathcal{E}/R)\,e^{-t_a/RC}$
(d) $(\mathcal{E}/R)\left(1 - e^{-t_a/RC}\right)e^{-t_a/RC}$
(e) $(\mathcal{E}/R)\left(1 - e^{-t_a/RC}\right)$