first (given)	*last (family)*

Name, *printed* as it appears in Canvas

Physics 2212 K

Summer 2019

Nine-digit Tech ID

Quiz

3A

- **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	a	b	c	d	e
2	a	b	c	d	e
3	a	b	c	d	e
4	a	b	c	d	e
5	a	b	c	d	e
6	a	b	c	d	e
7	a	b	c	d	e
	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 :
$$\frac{1}{R_{\rm eq}} = \sum \frac{1}{R_i}$$
$$C_{\rm eq} = \sum C_i$$

$$\vec{E} = k\frac{q}{r^2}\hat{r}$$
$$\vec{F} = k\frac{q_1q_2}{r^2}\hat{r}$$
$$\vec{F} = q\vec{E}$$
$$\vec{p} = q\vec{d}$$
$$\vec{\tau} = \vec{p}\times\vec{E}$$
$$U = -\vec{p}\cdot\vec{E}$$
$$|\vec{E}| \propto \frac{|\vec{p}|}{r^3}$$
$$\Phi_{\rm E} = \int \vec{E}\cdot d\vec{A}$$
$$\epsilon_0 \oint \vec{E}\cdot d\vec{A} = q_{\rm enclosed}$$
$$\oint \vec{E}\cdot d\vec{\ell} = -\frac{d\Phi_{\rm B}}{dt}$$
$$C = \frac{Q}{\Delta V}$$
$$C = \epsilon_0\frac{A}{d}$$
$$U = \tfrac{1}{2}C\,[\Delta V]^2$$
$$R = \rho\frac{\ell}{A}$$
$$\tau_{\rm C} = RC$$
$$u_{\rm E} = \tfrac{1}{2}\epsilon_0 E^2$$

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

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

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

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

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

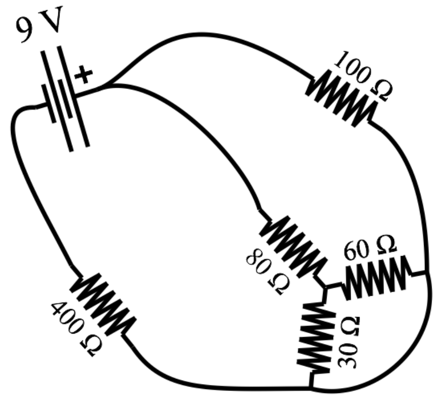
I. (16 points) An infinitely long cylindrical conducting wire has radius R. A current flows along the wire with non-uniform current density $\vec{J}$. The magnitude of the current density varies with distance, r, from the cylinder axis according to

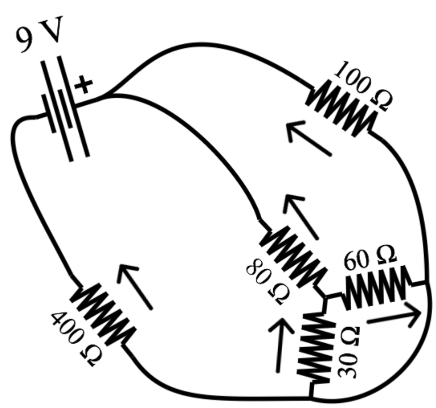
$$J = J_0 \frac{R}{r} e^{-r/R}$$

where J_0 is a positive constant.

What is the magnitude of the magnetic field at a distance $r = 2R$ from the center of the wire? Express your answer in terms of parameters defined in the problem and physical or mathematical constants.

II. (16 points) In the circuit shown, what is the current through the $400\,\Omega$ resistor?



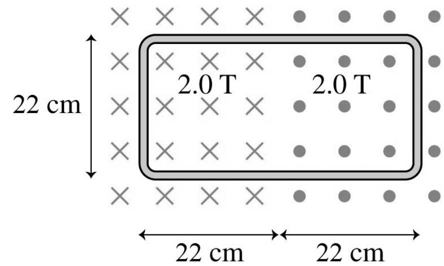


1. (6 points) If positive current directions are defined by the arrows as shown, and current through the $400\,\Omega$ resistor is I_{400}, *etc.*, which equation is a valid expression of Kirchhoff's Loop Law?

(a) $+9\,\text{V} + I_{80}\,(80\,\Omega) + I_{30}\,(30\,\Omega) + I_{60}\,(60\,\Omega) = 0$
(b) $+9\,\text{V} + I_{100}\,(100\,\Omega) + I_{60}\,(60\,\Omega) + I_{30}\,(30\,\Omega) - I_{400}\,(400\,\Omega) = 0$
(c) $+9\,\text{V} - I_{30}\,(30\,\Omega) - I_{60}\,(60\,\Omega) - I_{80}\,(80\,\Omega) - I_{100}\,(100\,\Omega) - I_{400}\,(400\,\Omega) = 0$
(d) $+9\,\text{V} + I_{80}\,(80\,\Omega) - I_{30}\,(30\,\Omega) + I_{400}\,(400\,\Omega) = 0$
(e) $+9\,\text{V} + I_{100}\,(100\,\Omega) + I_{60}\,(60\,\Omega) - I_{80}\,(80\,\Omega) = 0$

Initial:

III. (16 points) A conducting rectangular loop is 22 cm high, 44 cm wide, and has a resistance of $16\,\Omega$. Through the left half is a magnetic field of 2.0 T into the page, while through the right side is a magnetic field of 2.0 T out of the page, as shown. At time $t = 0$ the field magnitude into the left half begins to decrease at 0.50 T/s, while the magnitude out of the right half begins to increase as 0.50 T/s. What is the current in the loop 1.0 s later? If the current must be zero, prove it.

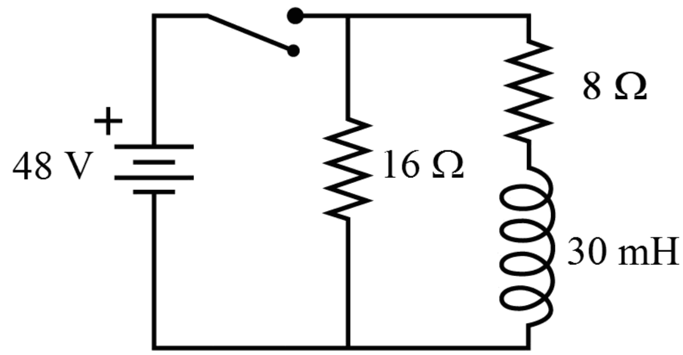


2. (6 points) In the problem above, what direction does current flow in the loop at time $t = 1.0\,\text{s}$?

(a) No direction, as current must be zero
(b) Counter-clockwise
(c) Clockwise in the left half, counter-clockwise in the the right half
(d) Clockwise
(e) Counter-clockwise in the left half, clockwise in the the right half

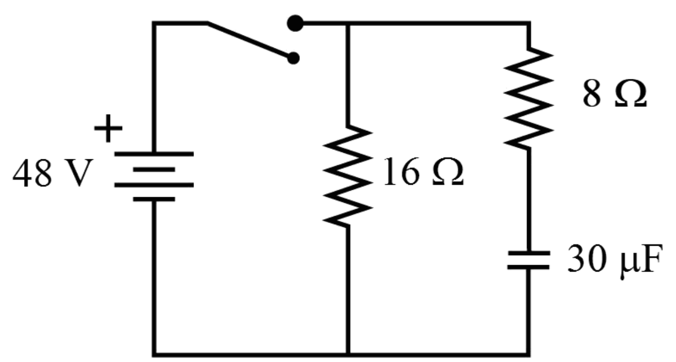
3. (8 points) A circuit is constructed with a 48 V battery, a switch, a 30 mH inductor, an 8 Ω and a 16 Ω resistor, as shown. The switch has been closed for a long time. What is the current through the 16 Ω resistor immediately upon opening the switch?

(a) 3.0 A
(b) 9.0 A
(c) 6.0 A
(d) 2.0 A
(e) Zero A



4. (8 points) A circuit is constructed with a 48 V battery, a switch, a 30 μF capacitor, an 8 Ω and a 16 Ω resistor, as shown.What is the current through the 16 Ω resistor after the switch has been closed for a long time?

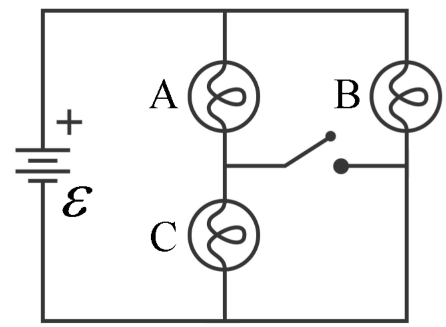
(a) 6.0 A
(b) 2.0 A
(c) 3.0 A
(d) 9.0 A
(e) Zero A



Initial:

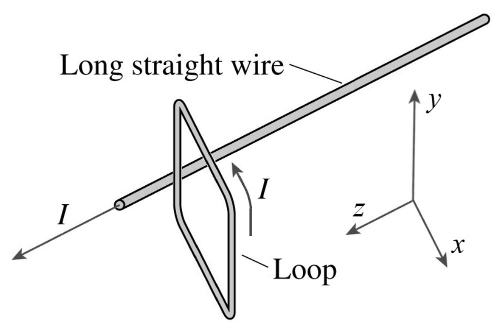
5. (8 points) The circuit shown to the right contains three light bulbs rated at 100 W. Compare the brightnesses of the bulbs after the switch has been closed to their original brightnesses, when the switch is open. *Hint:* Consider the potentials across the bulbs.

   (a) Bulb A becomes brighter, bulb B remains at the same brightness, and bulb C becomes dimmer.
   (b) Bulb A becomes dimmer, bulb B becomes dimmer, and bulb C becomes brighter.
   (c) Bulb A becomes dimmer, bulb B becomes brighter, and bulb C becomes brighter.
   (d) Bulb A becomes brighter, bulb B becomes brighter, and bulb C becomes dimmer.
   (e) Bulb A becomes brighter, bulb B becomes brighter, and bulb C becomes brighter.



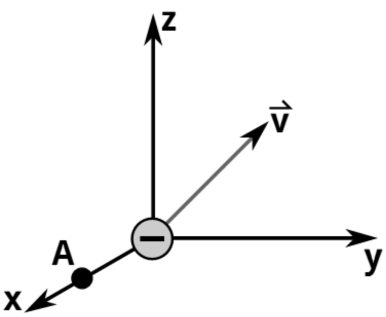
6. (8 points) A long straight wire carries current I in the $+z$ direction. A nearby square loop lies in the $x-y$ plane and carries a current I that is counter-clockwise when viewed from a position on the $+z$ axis, as shown. How, if at all, will the loop rotate if released from this position?

   (a) It will rotate counter-clockwise as viewed from the $+x$ axis.
   (b) It will rotate counter-clockwise as viewed from the $+y$ axis.
   (c) It will not rotate.
   (d) It will rotate clockwise as viewed from the $+y$ axis.
   (e) It will rotate clockwise as viewed from the $+x$ axis.



7. (8 points) A negatively-charged particle is moving in the yz-plane. At the moment when it passes through the origin, its velocity is given by

$$\vec{v} = \frac{1}{\sqrt{2}}\hat{\jmath} + \frac{1}{\sqrt{2}}\hat{k}$$



If a, b, and c are positive constants, what is the direction of the magnetic field at point A on the positive x-axis?

(a) $+b\hat{\jmath} - c\hat{k}$
(b) $+a\hat{\imath} - b\hat{\jmath}$
(c) $-c\hat{k}$
(d) $-a\hat{\imath} + b\hat{\jmath}$
(e) $-b\hat{\jmath} + c\hat{k}$