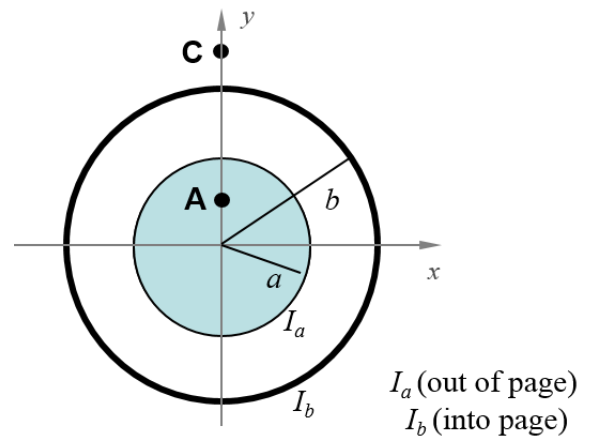


The next three questions pertain to the situation described below.

Consider two infinitely long, concentric cylinders, with their axes along the z -axis. The inner solid cylinder has radius $a = 0.16$ m and carries a current $I_a = 1.5$ A directed out of the page. This current is uniformly distributed throughout the cylinder. The outer (hollow) cylinder has radius $b = 0.32$ m, and carries current $I_b = 2.5$ A into the page as shown in the figure.



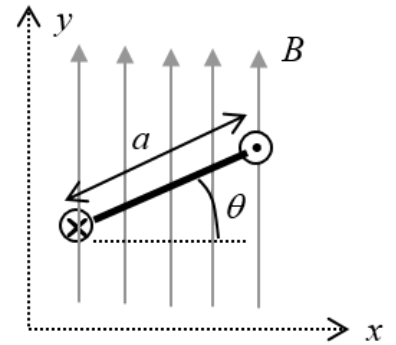
- 1) What is the magnitude of the magnetic field at point A ($y=0.08$ m) due to the current in the two cylinders?
 - a. $|B_A| = 1.88 \times 10^{-6}$ T
 - b. $|B_A| = 3.75 \times 10^{-6}$ T
 - c. $|B_A| = 2.5 \times 10^{-6}$ T
 - d. $|B_A| = 5.31 \times 10^{-6}$ T
 - e. $|B_A| = 9.37 \times 10^{-7}$ T

- 2) What is the direction of the magnetic field at point A ($y=0.08$ m) due to the current in the two cylinders?
 - a. $-x$
 - b. $+y$
 - c. $-y$

- 3) What is the magnitude of the magnetic field at point C ($y=0.48$ m) due to the current in the two cylinders?
 - a. $|B_C| = 3.12 \times 10^{-7}$ T
 - b. $|B_C| = 1.67 \times 10^{-6}$ T
 - c. $|B_C| = 4.17 \times 10^{-7}$ T

The next three questions pertain to the situation described below.

A square conducting loop of wire, of side $a = 0.6$ m, carries an electrical current $I = 2.8$ A as indicated in the figure. The wire in the x - y plane makes an angle $\theta = 25^\circ$ relative to the x axis as shown in the figure. The loop is placed in a region with a uniform external magnetic field in the positive y direction.



4) What is the magnitude of the magnetic moment for this current loop?

- a. $|\boldsymbol{\mu}| = 1.01 \text{ A m}^2$
- b. $|\boldsymbol{\mu}| = 0.914 \text{ A m}^2$
- c. $|\boldsymbol{\mu}| = 0.426 \text{ A m}^2$

5) For which value(s) of the angle θ , in the range $0^\circ \leq \theta \leq 360^\circ$, is the torque exerted on the loop equal to zero?

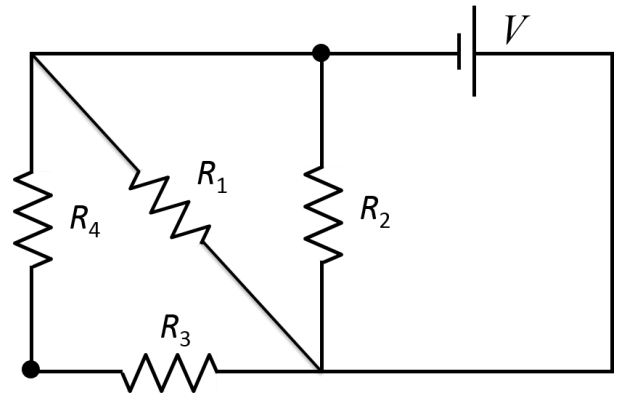
- a. $\theta = 270^\circ$ only
- b. $\theta = 90^\circ$ only
- c. $\theta = 90^\circ$ or $\theta = 270^\circ$
- d. $\theta = 0^\circ$ or $\theta = 180^\circ$
- e. $\theta = 0^\circ$ only

6) Which of the following orientations has the greatest potential energy?

- a. $\theta = 120^\circ$
- b. $\theta = 0^\circ$
- c. $\theta = 60^\circ$

The next four questions pertain to the situation described below.

Consider the electrical circuit shown to the right. It consists of an ideal battery $V = 48 \text{ V}$, and four resistors, whose values are: $R_1 = 16 \ \Omega$, $R_2 = R_3 = R_4 = 12 \ \Omega$.



7) Resistors R_1 and R_2 are in

- a. Neither series nor parallel
- b. Series
- c. Parallel

8) What is the equivalent resistance of the four resistors in this circuit?

- a. $52 \ \Omega$
- b. $3.2 \ \Omega$
- c. $5.33 \ \Omega$
- d. $34 \ \Omega$
- e. $9.23 \ \Omega$

9) What is the magnitude of the current I_3 through resistor R_3 ?

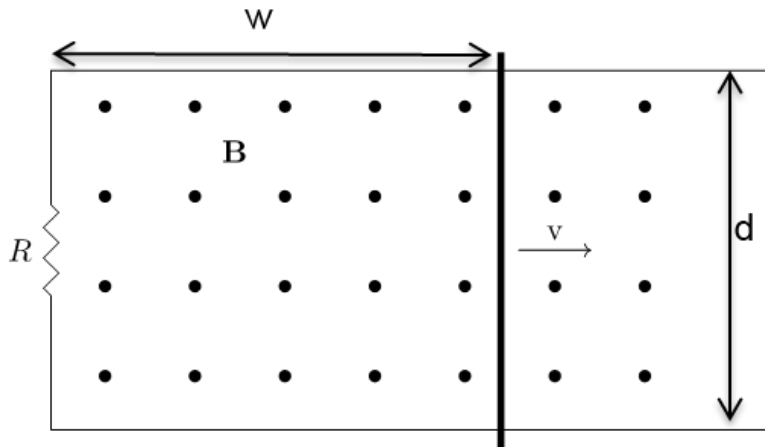
- a. $|I_3| = 9.01 \text{ A}$
- b. $|I_3| = 2 \text{ A}$
- c. $|I_3| = 4 \text{ A}$

10) In order to include the effects of a physical battery, we could add a resistor R_{battery} . This resistor should be placed

- a. in parallel with the ideal battery.
- b. in series with the ideal battery.

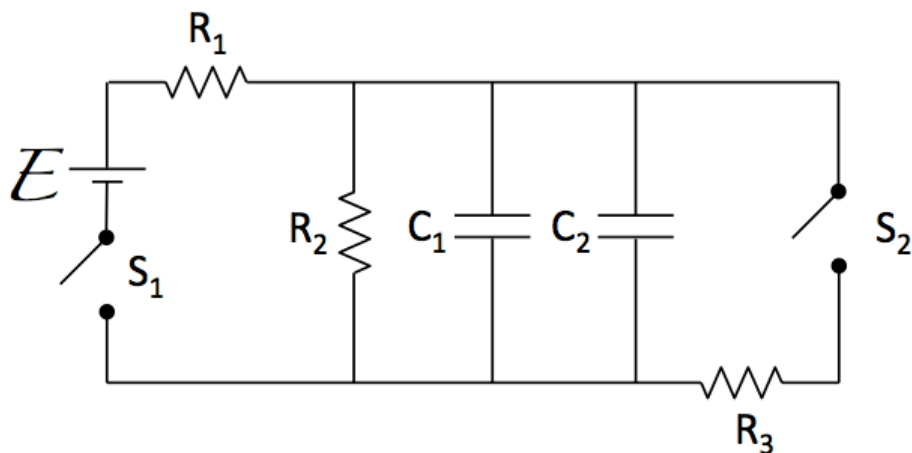
The next three questions pertain to the situation described below.

A conducting bar of mass $m=0.3$ kg slides with negligible friction along a pair of horizontal conducting tracks separated by a distance $d = 0.15$ m, as shown in the figure below. The left side of the loop contains a resistor with resistance $R=30 \Omega$. There is a constant magnetic field, $B = 2$ T, directed out of the page.



- 11) What is the current through the resistor when the metallic bar is a distance $w = 0.225$ m from the end sliding with a constant speed $v = 6$ m/s?
- $I = 0.06$ A
 - $I = 0.09$ A
 - $I = 0.00225$ A
- 12) What direction does the current flow, when the bar is sliding to the right with a constant speed $v = 6$ m/s?
- Counter clockwise, down through the resistor.
 - Clockwise, up through the resistor.
- 13) The resistor R represents the filament of an incandescent bulb that requires 1.5 W of power to light. What is the minimum speed v at which the bar needs to slide in order to light the bulb?
- $v = 6.67$ m/s
 - $v = 2.1$ m/s
 - $v = 0.45$ m/s
 - $v = 3.16$ m/s
 - $v = 22.4$ m/s

The next five questions pertain to the situation described below.



Consider the electrical circuit shown above. It consists of two switches, an ideal battery $E = 24 \text{ V}$, three resistors $R_1 = 20 \Omega$, $R_2 = 40 \Omega$, $R_3 = 60 \Omega$, and two capacitors $C_1 = 30 \mu\text{F}$, $C_2 = 50 \mu\text{F}$. The capacitors are initially uncharged, and both switches are open.

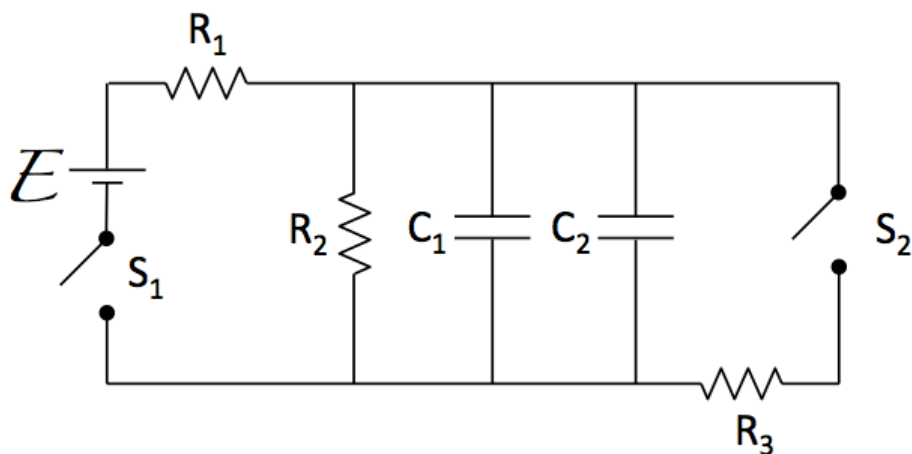
14) At time $t=0$, the switch S_1 is closed (S_2 remains open). Which statement can be made for all time $t>0$ about the relationship between the currents I_1 and I_2 , which flow through the resistors R_1 and R_2 , respectively?

- a. $I_1 \geq I_2$ for all $t > 0$.
- b. Neither of the other two statements hold for all time $t > 0$.
- c. $I_1 \leq I_2$ for all $t > 0$.

15) After a very long time, what is the relationship between the currents I_1 and I_2 ?

- a. $I_1 = I_2$
- b. $I_1 = I_2 R_1 / (R_1 + R_2)$
- c. $I_1 = I_2 R_2 / (R_1 + R_2)$

16) (Figure repeated and text repeated from previous page.)



Consider the electrical circuit shown above. It consists of two switches, an ideal battery $E = 24 \text{ V}$, three resistors $R_1 = 20 \Omega$, $R_2 = 40 \Omega$, $R_3 = 60 \Omega$, and two capacitors $C_1 = 30 \mu\text{F}$, $C_2 = 50 \mu\text{F}$. The capacitors are initially uncharged, and both switches are open. At time $t=0$, the switch S_1 is closed (S_2 remains open).

After a very long time, what is the charge stored on capacitor C_1 ?

- a. $Q_1 = 450 \mu\text{C}$
- b. $Q_1 = 1280 \mu\text{C}$
- c. $Q_1 = 480 \mu\text{C}$
- d. $Q_1 = 720 \mu\text{C}$
- e. $Q_1 = 240 \mu\text{C}$

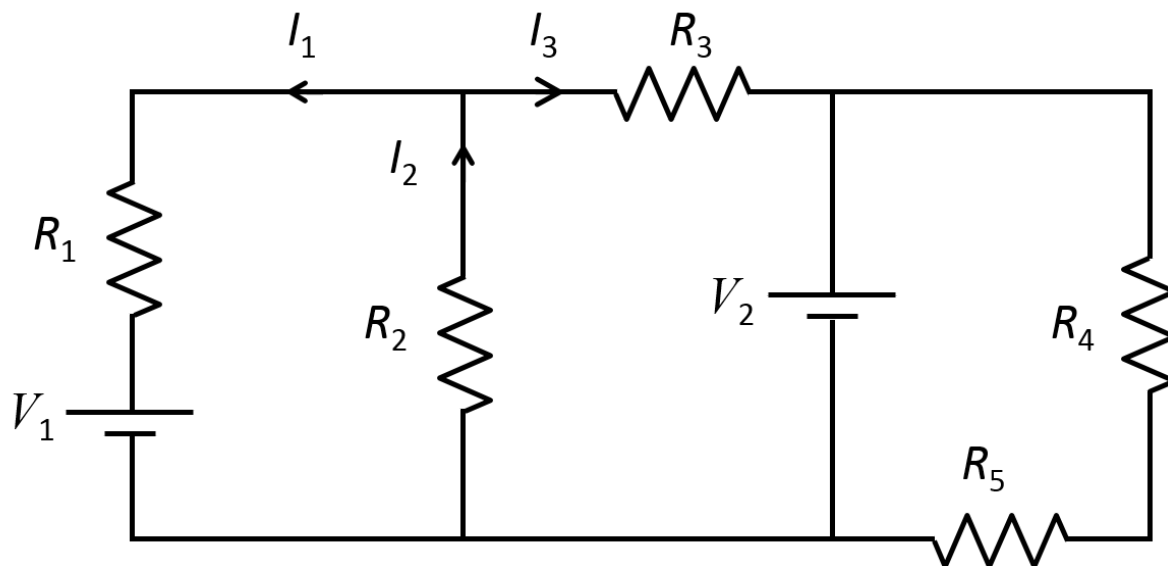
17) After a very long time, the switch S_1 is opened at exactly the same time switch S_2 is closed. What is the current I_3 that flows through resistor R_3 immediately after switch S_2 is closed?

- a. $I_3 = 0.667 \text{ A}$
- b. $I_3 = 0.16 \text{ A}$
- c. $I_3 = 0.267 \text{ A}$

18) After switch S_1 is opened and switch S_2 is closed. What is the time constant τ that determines the rate at which the capacitors discharge?

- a. $\tau = 0.003 \text{ s}$
- b. $\tau = 0.00192 \text{ s}$
- c. $\tau = 0.00112 \text{ s}$
- d. $\tau = 0.0048 \text{ s}$
- e. $\tau = 0.00244 \text{ s}$

The next two questions pertain to the situation described below.



Consider the electrical circuit shown above. It consists of two identical ideal batteries, $V_1 = V_2 = 36 \text{ V}$, and five resistors.

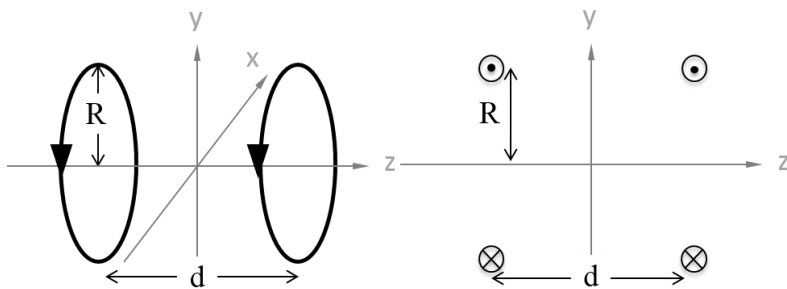
19) Which of the following equations is not valid?

- a. $I_2 R_2 + I_3 R_3 + V_2 = 0$
- b. $I_1 R_1 + I_2 R_2 - V_1 = 0$
- c. $I_2 = I_1 + I_3$

20) Suppose the resistor R_3 is shorted out, so that it acts like a wire. What can we say about the current labelled I_1 ?

- a. I_1 is zero.
- b. I_1 is negative.
- c. I_1 is positive.

The next two questions pertain to the situation described below.



Two identical circular conducting loops with radius R and negligible thickness are placed a distance d apart and carry current I in the same counterclockwise when viewed from the positive z axis, i.e. the current at the top of the loop comes out of the page, the current at the bottom of the loop goes into the page. The axes of both loops are oriented along the z -axis, as shown in the figure.

21) What is the direction of the magnetic field at the point on the z axis midway between the center of the two loops ($z=0$)?

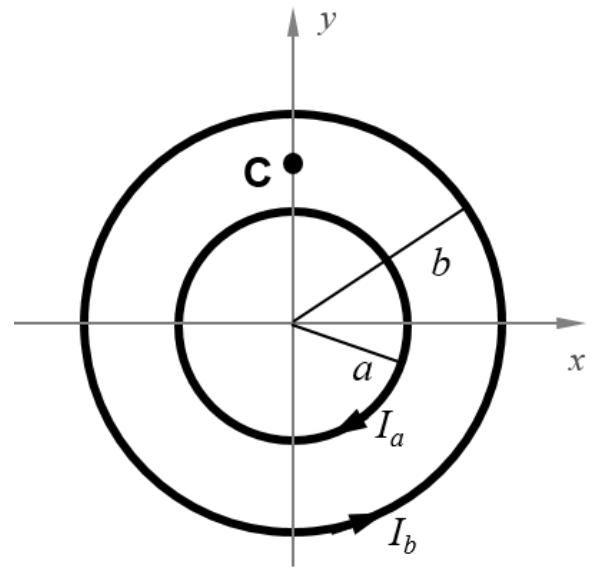
- a. right ($+z$)
- b. zero
- c. left ($-z$)

22) What is the direction of the net force on the left loop, due to the magnetic field produced by the right loop.

- a. zero
- b. left ($-z$)
- c. right ($+z$)

The next two questions pertain to the situation described below.

Consider two infinitely long, concentric **solenoids**, with their axes along the z-axis. Each has 2500 turns/meter. The inner solenoid has radius $a = 0.4$ m and carries a current $I_a = 2.5$ A clockwise. The outer solenoid has radius $b = 0.8$ m, and carries current $I_b = 6$ A counter clockwise as shown in the figure.



23) What is the magnitude of the magnetic field at point C ($y=0.6$ m) due to the current in the two solenoids?

- a. $|B_C| = 0.00785$ T
- b. $|B_C| = 0.0188$ T
- c. $|B_C| = 0.011$ T

24) What is the direction of the magnetic field at point C ($y=0.6$ m) due to the current in the two solenoids?

- a. Into the page.
- b. Up (+y)
- c. Out of the page.

25) A muon and an electron are travelling parallel to each other with identical kinetic energy. They enter a region with uniform magnetic field perpendicular to the direction of motion of both particles. What is the ratio of the radius of the muon orbit to the electron orbit ($r_{\text{muon}}/r_{\text{electron}}$)? Note electrons and muons have the same charge $q = -1.6 \times 10^{-19} \text{ C}$ and $m_{\text{electron}} = 9.1 \times 10^{-31} \text{ kg}$ and $m_{\text{muon}} = 1.9 \times 10^{-28} \text{ kg}$.

a. $r_{\text{muon}}/r_{\text{electron}} = 209$

b. $r_{\text{muon}}/r_{\text{electron}} = 0.07$

c. $r_{\text{muon}}/r_{\text{electron}} = 14.4$