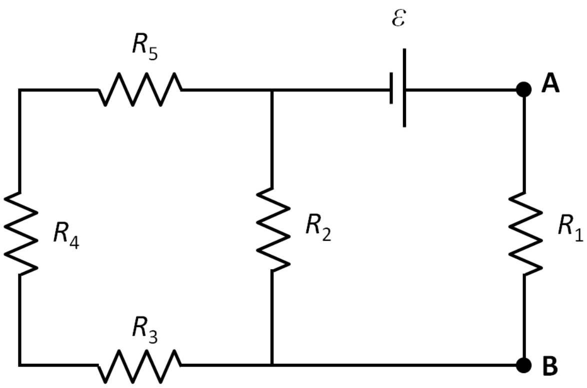
The next three questions pertain to the situation described below.

Consider an electrical circuit shown. It consists of an ideal battery and five resistors, whose values are: $\varepsilon = 12$ V, $R_1 = 4$ Ω, $R_2 = R_3 = R_4 = R_5 = 3$ Ω.



1) What is the ratio I_2/I_3 of the currents flowing through R_2 and R_3?

a. $I_2/I_3 = 0.333$
b. $I_2/I_3 = 1$
c. $I_2/I_3 = 3$

2) What is the electric potential difference between the points **A** and **B**?

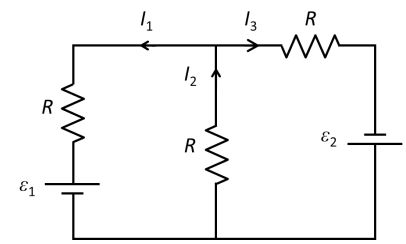
a. $V_A - V_B = 12$ V
b. $V_A - V_B = 7.68$ V
c. $V_A - V_B = -7.68$ V
d. $V_A - V_B = -3$ V
e. $V_A - V_B = 3$ V

3) If the ideal battery is now replaced with a non-ideal battery of the same voltage, how would the current I_1 through R_1 change?

a. stay the same
b. increase
c. decrease

The next two questions pertain to the situation described below.

Consider an electrical circuit shown. It consists of two ideal batteries and three identical resistors, whose values are: $\varepsilon_1 = 12$ V, $\varepsilon_2 = 15$ V, $R = 5\ \Omega$. The positive directions for the currents I_1, I_2 and I_3 are indicated by the directions of the arrows.



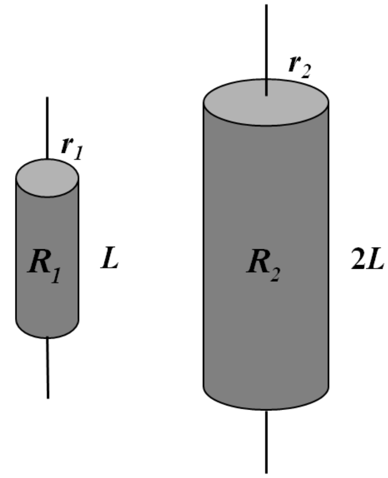
4) Which of the following equations is <u>not</u> valid?

a. $I_1 R_1 + I_2 R_2 - \epsilon_1 = 0$
b. $I_2 = I_1 + I_3$
c. $I_2 R_2 + I_3 R_3 - \epsilon_2 = 0$

5) What is the current I_1?

a. $I_1 = 0.6$ A
b. $I_1 = -0.6$ A
c. $I_1 = 2.6$ A
d. $I_1 = -7.8$ A
e. $I_1 = -2.6$ A

Two cylindrical resistors are made of the same material with known resistivity. Their lengths are L and $2L$, respectively, as shown. If the ratio of their resistance values is $R_2/R_1 = 4$, what is the ratio of their radii r_2/r_1?

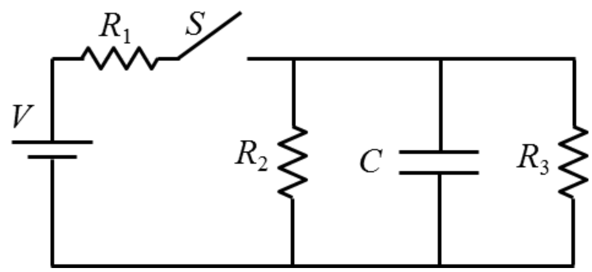


6)

a. $r_2/r_1 = 1.41$
b. $r_2/r_1 = 0.5$
c. $r_2/r_1 = 0.707$

The next two questions pertain to the situation described below.

A circuit is constructed with three resistors and one capacitor as shown. The values for the resistors are: $R_1 = R_2 = R_3 = 6$ Ω. The capacitance is $C = 50$ μF and the battery voltage is $V = 10$ V. The switch S is initially open.



7) What is the magnitude of the current through $\boldsymbol{R_2}$ immediately after the switch is closed?

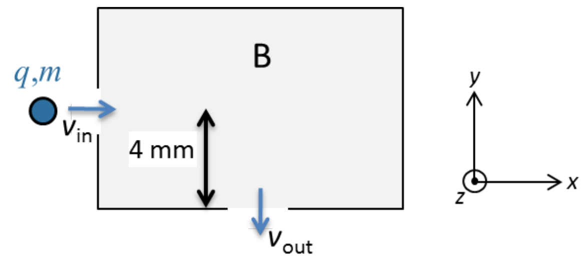
a. 0 A
b. 1.67 A
c. 3.33 A

8) After being closed for a long time the switch is opened again. What is the charge on the capacitor at a time 200 μs after the switch is opened?

a. 358 μC
b. 132 μC
c. 85.6 μC
d. 119 μC
e. 43.9 μC

The next two questions pertain to the situation described below.

A particle of charge $q = 20\ \mu C$ moving with constant velocity $v = 50$ m/s $\hat{x}$ enters a region containing a constant magnetic field of magnitude 12 T. The particle leaves the field region with a velocity in the -y direction, having moved a vertical distance of 4 mm, as shown below.



9) In what direction could the magnetic field point in order to make the particle have the trajectory shown above?

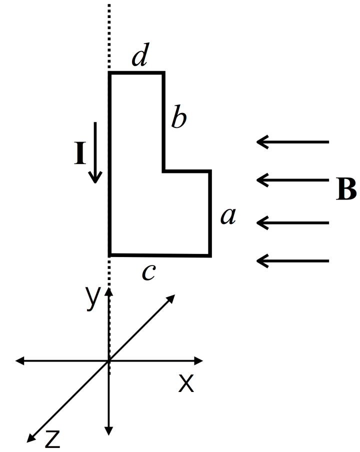
a. +y direction
b. -z direction
c. +z direction

10) Assume that the particle's initial velocity is perpendicular to the direction of the magnetic field, and that it moves only in the x-y plane. Find the mass of the particle.

a. 0.96×10^{-8} kg
b. 3.84×10^{-8} kg
c. 1.92×10^{-8} kg
d. 9.11×10^{-31} kg
e. 1.66×10^{-27} kg

The next three questions pertain to the situation described below.

A wire loop is attached to an axis (dotted line in Figure) about which it can freely rotate. There is a constant magnetic field and a current flowing counter-clockwise in the wire as shown in the image. The length of the line segments are a, b, c, and d as indicated.



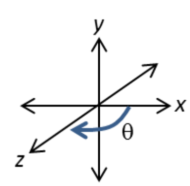
11) What is the net torque about the axis on the wire loop?

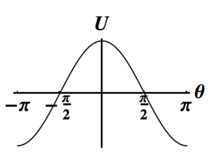
a. 0
b. $IB(a+b+c+d)\hat{y}$
c. $-IB(ac+bd)\hat{y}$
d. $IB(ac+bd)\hat{y}$
e. $-IB(a+b+c+d)\hat{y}$

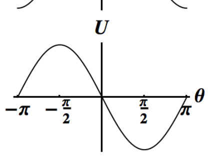
12) The loop is allowed to relax to its lowest energy position. What is the work done on the loop by the magnetic field?

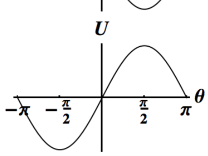
a. $-IB(ac+bd)$
b. $IB(a+b+c+d)$
c. $-IB(a+b+c+d)$
d. $2IB(a+b+c+d)$
e. $IB(ac+bd)$

13) Which of these sketches best represents the potential energy as a function of the rotation of the wire loop? (The angle $\theta = 0$ initially when the loop is in the x-y plane, and increases with clockwise rotation around the y-axis, as depicted at right).



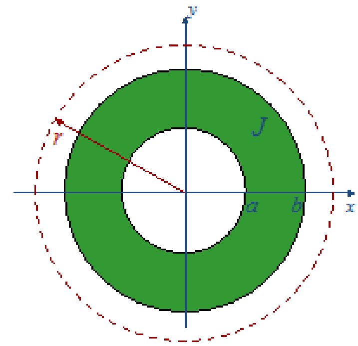
a.


b.


c.


The next two questions pertain to the situation described below.

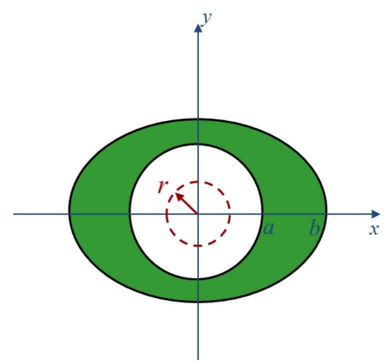
A conducting cylinder is oriented along the z-axis as shown in the picture. The inner radius is a = 4 cm, the outer radius is b = 8 cm, and the current density through the cylinder is J = 30 A/m^2.



14) What is the magnitude of the magnetic field at a distance r = 12 cm from the center of the cylinder?

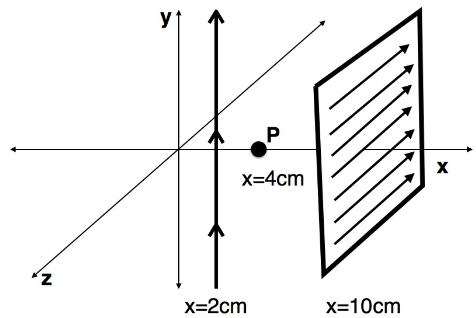
a. 10.1 x 10^{-5} T
b. 2.51 x 10^{-7} T
c. 7.54 x 10^{-5} T
d. 10.1 x 10^{-7} T
e. 7.54 x 10^{-7} T

15) Suppose that the cylinder is deformed as shown. The total current remains the same. Which of these statements about the interior of the cylinder (i.e., $r < a$) is FALSE?



a. The integral $\oint \vec{B} \cdot d\vec{\ell}$ over the dotted line to the right is equal to zero.
b. The magnetic field is no longer zero for $0 < r < a$.
c. Ampere's law can be used to determine the magnetic field.

A wire with current I_W = 1 A in the y-direction is situated on the x-axis, a distance 2 cm from the origin. An infinite sheet of current with uniform current density J_S = 2 A/m in the –z direction crosses the x-axis at a distance 10 cm from the origin. [Note that $J \equiv nI$, where n is the number of wires per unit length].

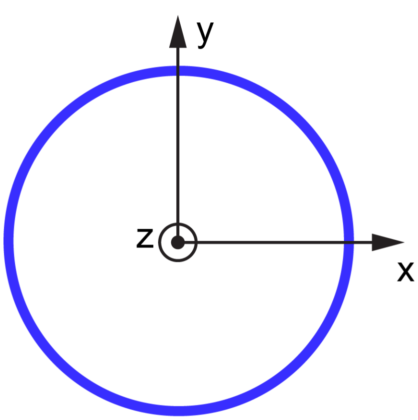


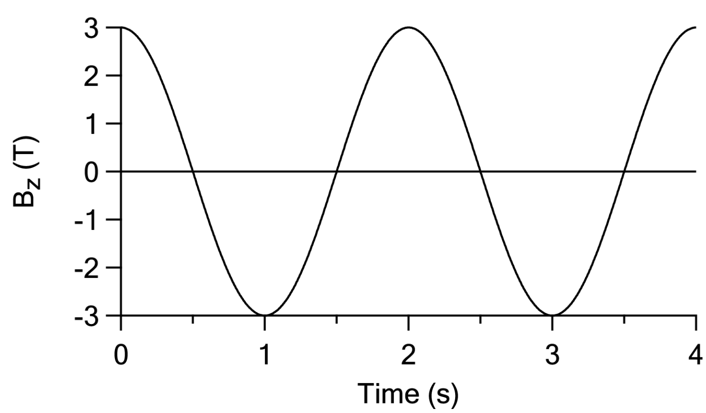
16) What is the value of the magnetic field at a point P on the x-axis 4 cm from the origin?

a. $(-1\text{x}10^{-6}\hat{y} + 1.26\text{x}10^{-6}\hat{z})$ T
b. $(-2\text{x}10^{-6}\hat{y} - 1\text{x}10^{-7}\hat{z})$ T
c. $(1.26\text{x}10^{-6}\hat{y} - 1\text{x}10^{-5}\hat{z})$ T
d. $(-1.26\text{x}10^{-6}\hat{y} + 1\text{x}10^{-5}\hat{z})$ T
e. $(2\text{x}10^{-6}\hat{y} + 1\text{x}10^{-7}\hat{z})$ T

The next four questions pertain to the situation described below.

A circular conducting metal loop of radius 3 cm, lying in the xy-plane, is placed in a spatially uniform, but time-varying magnetic field B_Z, which is oriented parallel to the z-direction (Note, the positive z-direction is pointed out of the page.) The loop has a resistance of 5 Ω. The magnetic field has the sinusoidal time dependence shown on the right: $B_z(t) = B_0 cos(2\pi f t)$, where B_0 = 3 T and f = 0.5 Hz.





17) Which way is the current circulating in the loop at t = 0.5 s?

a. Clockwise
b. There is no current at this time.
c. Counter-clockwise

18) What is the magnetic flux through the loop at t = 2.0 s?

a. 0.0054 T-m^2
b. 0.00848 T-m^2
c. 0.0027 T-m^2

19) Which way is the current circulating in the loop at t = 1.0 s?

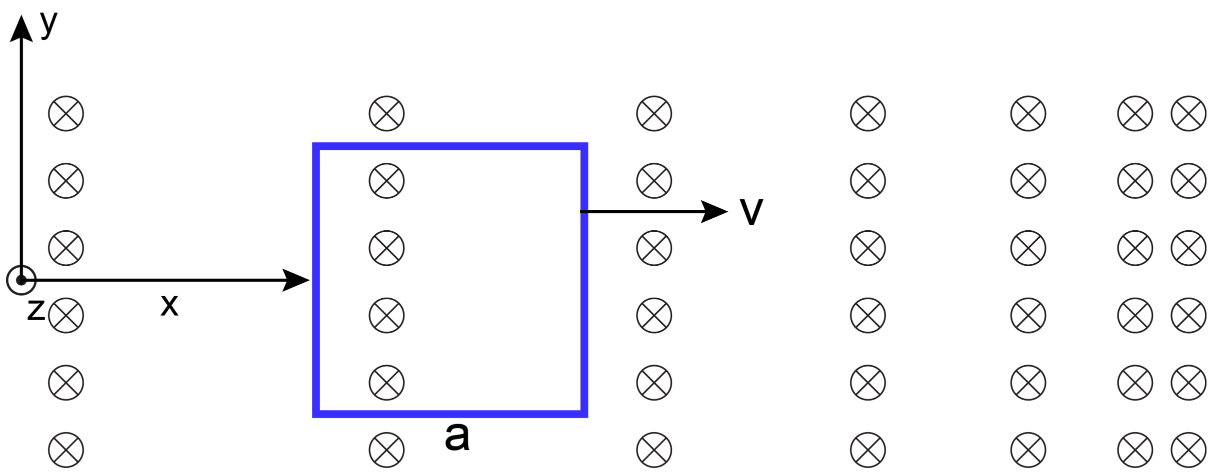
a. There is no current at this time.
b. Clockwise
c. Counter-clockwise

20) Calculate the magnitude of the circulating current at $t = 0.8$ s. (Note: Make sure to either set your calculator to radians, or convert the phase into degrees.)

a. 9.97×10^{-4} A
b. 1.11 A
c. 0.00313 A
d. 0.0017 A
e. 0.00533 A

The next two questions pertain to the situation described below.

A square conducting metallic loop is moving in the x-direction through a region of space with a magnetic field pointing along the negative z-direction. The loop has dimension a = 20 cm, and resistance of 2 Ω. The magnitude of the magnetic field increases linearly in the x-direction $B_z = Ax$, where A = 100 T/m.



21) Calculate the flux through the loop when the left edge of the loop is located at x = 0.7 m. Only consider the flux due to the external field.

a. 4 T-m^2
b. 4.9 T-m^2
c. 3.2 T-m^2
d. 6.4 T-m^2
e. 2.8 T-m^2

22) Calculate the force on the loop when the left edge of the loop is located at x = 2.3 m, and moving with velocity v = 3 m/s.

a. F = -24 N $\hat{x}$
b. F = -1.2 × 10^6 N $\hat{x}$
c. F = -276 N $\hat{x}$
d. F = -3170 N $\hat{x}$
e. F = -48 N $\hat{x}$