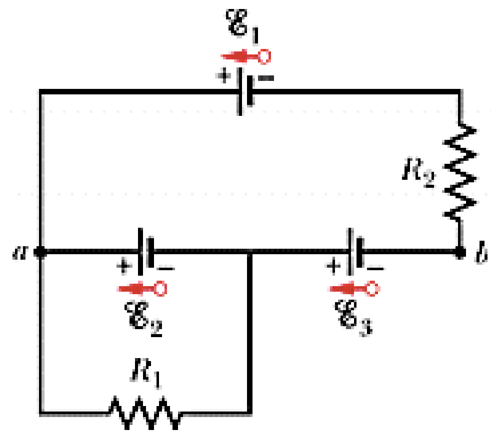
1. A cylindrical copper rod of length *L* and cross-sectional area *A* is re-formed to twice its original length with no change in volume. If the resistance between its ends was originally *R*, what is it now?
   (a) R/2
   (b) R
   (c) R/4
   (d) 2R
   (e) 4R

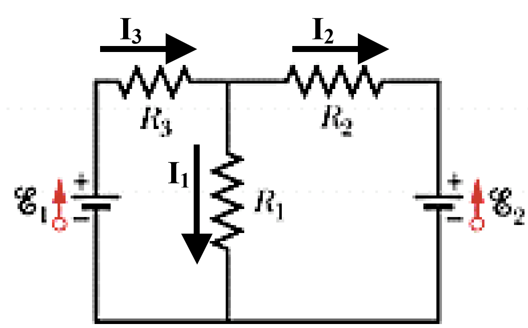
2. The current density across a cylindrical conductor of radius *R* varies according to the equation $J = J_0(r/R)$, where *r* is the distance from the central axis. Thus, the current density is zero at the axis ($r = 0$) and increases linearly to J_0 at the surface ($r = R$). Calculate the current in terms of J_0 and *R*.
   (a) $i = (\square R^2 J_0)/2$
   (b) $i = (2\square R^2 J_0)/3$
   (c) $i = (\square R^2 J_0)/6$
   (d) $i = (\square R^3 J_0)/3$
   (e) $i = (\square R^3 J_0)/6$

3. In the adjacent figure, $\mathcal{E}_1$ = 6.0 V, $\mathcal{E}_2$ = 5.5 V, $\mathcal{E}_3$ = 2.0 V, R_1 = 1□, and R_2 = 6□. All batteries are ideal. Find the current in resistor R_1.



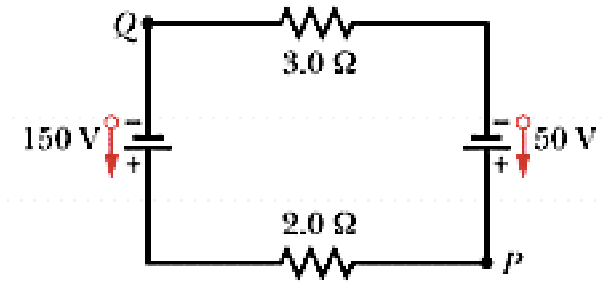
   (a) 0.0333A
   (b) 3.25 A
   (c) 1.24 A
   (d) 5.5 A
   (e) 3 A

4. A student tries to analyze the circuit shown in the adjacent figure. She chooses current directions as shown. Which of the following equations is correct with <u>the currents as chosen</u>?

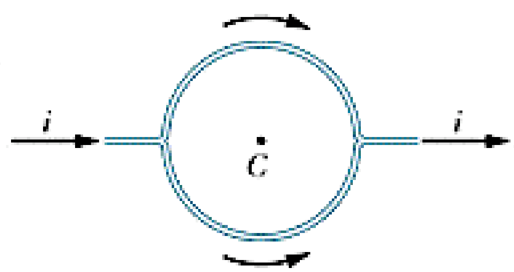


   (a) $-I_1R_1 + \mathcal{E}_1 + I_3R_3 = 0$
   (b) $-I_2R_2 + \mathcal{E}_1 + I_3R_3 = 0$
   (c) $-I_1R_1 + \mathcal{E}_2 + I_3R_3 = 0$
   (d) $-I_1R_1 + \mathcal{E}_1 - I_3R_3 = 0$
   (e) $-I_1R_1 + \mathcal{E}_2 - I_2R_2 = 0$

5. In the adjacent figure, if the potential at point *P* is 120 V, what is the potential at point *Q*?
   (a) 0 V
   (b) 130 V
   (c) 45 V
   (d) 110 V
   (e) 10 V

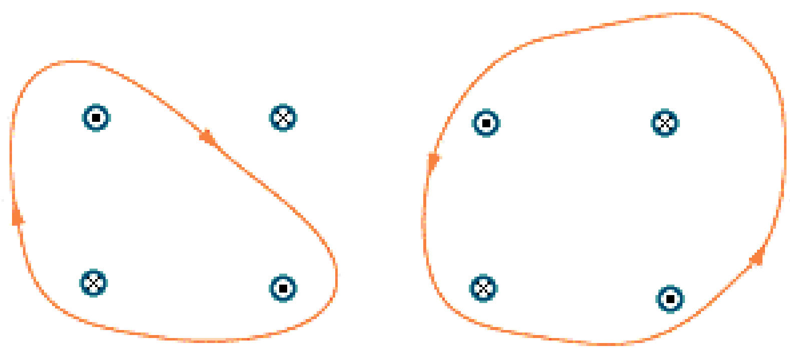


6. A straight conductor carrying a current *i* splits into identical semicircular arcs as shown in the adjacent figure. The radius of the arcs is R. What is the magnetic field at the center *C* of the resulting circular loop?



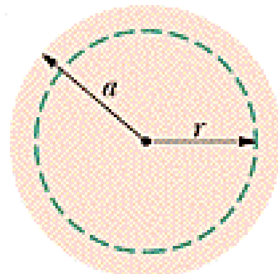
   (a) The field is zero.
   (b) $\mu_0 i/2R$
   (c) None of these options is correct.
   (d) $\mu_0 i/2\pi R$
   (e) $\mu_0 i/2R^2$

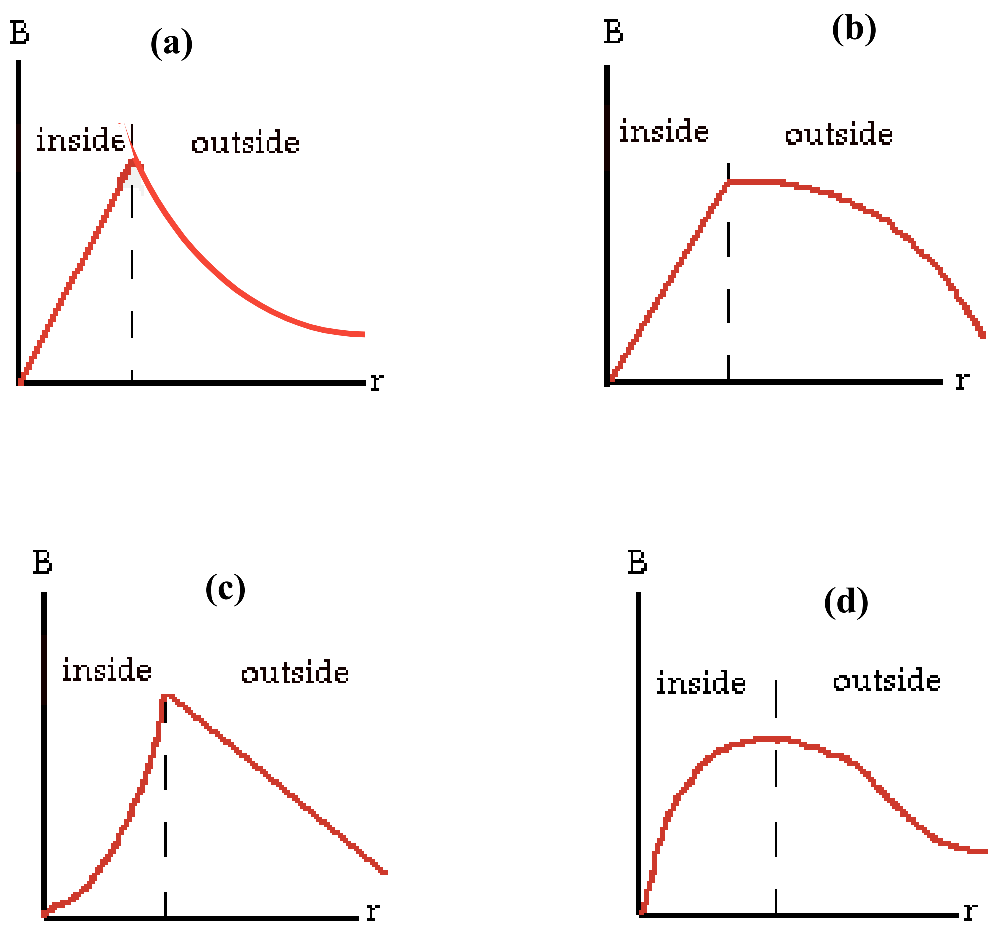
7. Each of the eight conductors in the figure below carries 1.7 A of current into or out of the page (the figure uses the usual convention to indicate this). Two paths are indicated for the line integral $\oint_C \vec{B} \cdot d\vec{l}$. What is the value of the integral for the clockwise path at the left?



(a) +3.16 x 10^{-6} T · m
(b) –8.14 x 10^{-6} T · m
(c) +2.12 x 10^{-6} T · m
(d) –3.12 x 10^{-6} T · m
(e) –2.14 x 10^{-6} T · m

8. The figure below shows a cross section of a long cylindrical conductor of radius *a*, carrying a uniformly distributed current. Choose the correct plot of *B*(*r*), where *r* measures the distance from the cylinder axis – the dashed line in each plot shows *r* = *a*.





(e) None of the plots are correct.

9. A square wire loop that is free to move carries some constant current. It is held so that the normal to its plane makes an angle of 20^0 with a uniform magnetic field. How does the loop behave when it is released?
   (a) It rotates so that its dipole moment is aligned with the magnetic field.
   (b) It rotates so that its dipole moment points perpendicular to the magnetic field.
   (c) It rotates so that the magnetic field lies in the plane of the loop.
   (d) It does not move at all.
   (e) It rotates so that magnetic field becomes perpendicular to the plane of the loop, and it simultaneously accelerates in the direction of the magnetic field.

10. A particle of charge **Q** = +2 C has an instantaneous velocity **v** = (4**i** – 3**j)** m/s and is moving through a magnetic field **B** = (4**k) T**. Determine the magnitude of the instantaneous magnetic force on the particle.
   (a) 10 N
   (b) 20 N
   (c) 30 N
   (d) 40 N
   (e) 60 N

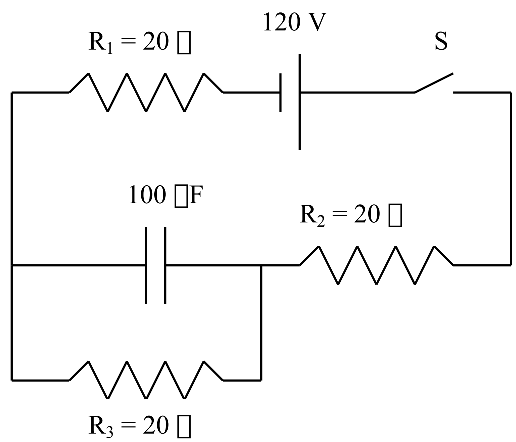
11. A wire 0.2 m long lying along the x axis carries a current of 1.60 A in the positive x direction, through a magnetic field **B** = (0.0030 T) **j** + (0.010 T) **k**. Find the force on the wire.

    (a) +0.0045 N **j** – 0.00096 N **k**
    (b) -0.0032 N **j** + 0.00096 N **k**
    (c) Zero
    (d) +0.0042 N **i** – 0.00096 N **j**
    (e) +0.0023 N **i** – 0.00096 N **k**

12. A car battery with a 12 V emf has an internal resistance of 0.050 Ω. If it supplies a current of 20 A to the car circuitry, what is the potential difference across its terminals?

    (a) 9.1 V
    (b) 12 V
    (c) 14.6 V
    (d) 11 V
    (e) 10.1 V

In the circuit shown below, the capacitor is initially uncharged and the switch S is is initially open. It is closed at t = 0. Answer questions 13-15 based upon this information.



13. Immediately after the switch is closed, determine the current through the 20Ω resistor **(R_3)** that is in parallel with the capacitor.

    (a) 0 A
    (b) 1 A
    (c) 2 A
    (d) 3 A
    (e) 4 A

14. A long time after the switch has been closed, determine the current through the battery.

    (a) 0 A
    (b) 1 A
    (c) 2 A
    (d) 3 A
    (e) 4 A

15. A long time after the switch has been closed, it is opened. How much time after this opening of the switch does the charge on the capacitor drop to 37 % of its maximum value?

    (a) 1 ms
    (b) 2 ms
    (c) 3 ms
    (d) 4 ms
    (e) 6 ms

16. A mass spectroscopist observes the circular motion of two charged ions entering a region of uniform magnetic field. If both ions entered the magnetic field region with the same speed, which ion would follow an orbit of larger radius?
    (a) The heavier ion.
    (b) The lighter ion.
    (c) The ion with less charge.
    (d) The ion with a smaller value of (charge/mass).
    (e) The ion with greater charge.

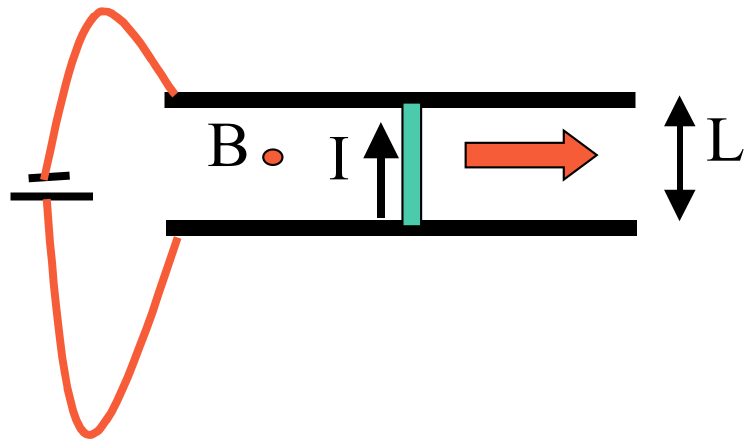
17. A proton (charge = +e) travelling at some finite speed enters a region that contains a uniform magnetic field **B** and a uniform electric field **E** that are perpendicular to each other and also to the initial velocity **v** of the particle. Which of the following conditions is neccesary for the proton to continue moving without any change in velocity?
    (a) This is impossible – the proton's velocity would have to change.
    (b) B = eE
    (c) EB = ev
    (d) v= E/B
    (e) ev = E/B

18. Why does the resistance of a metal wire increase when the wire gets hotter?
    (a) The electrons in the wire have more kinetic energy so that their drift speed increases.
    (b) The ions in the metal vibrate more so that electrons in the wire undergo more scattering from these ions.
    (c) The statement above is actually incorrect – the resistance of a metal wire decreases when the wire gets hotter.
    (d) The electrons in the wire have less kinetic energy so that their drift speed decreases.
    (e) The increased temperature makes ions in the metal move freely around the metal – this causes the electrons to undergo more scattering.

19. Rebecca connects two light bulbs in parallel across a **real** battery (i.e. the battery has some internal resistance). She removes one of the bulbs from its socket. What happens to the current flowing through the remaining bulb?

    (a) It stays the same.
    (b) It increases.
    (c) It decreases.
    (d) We need to know the value of the internal resistance to say anything about this.
    (e) We need to know more about the resistances of the bulb to say anything about this.

20. A Navy engineer designs a test "railgun" with the characteristics shown in the adjacent figure. The projectile is a straight rod of length L, mass m and carries a constant current I in the presence of a uniform magnetic field B that points out of the page and is present everywhere. If the projectile starts from rest and exits the railgun after a time t, what is its kinetic energy upon exit?



(a) $IBLt$

(b) $\frac{1}{2}IBLt^2$.

(c) $\frac{1}{2}\frac{IBLt^2}{m}$.

(d) $\frac{1}{2}\frac{(IBLt)^2}{m}$

(e) $\frac{1}{2}m(IBLt)^2$