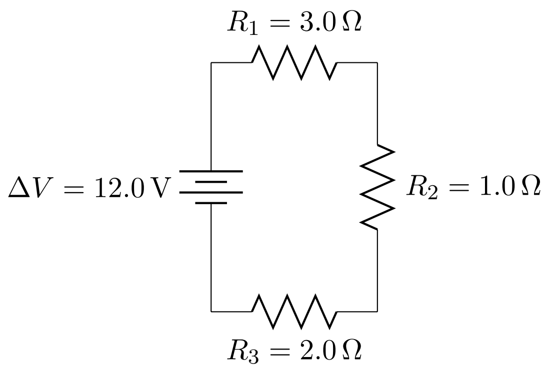
AP PHYSICS 2 & C: CIRCUIT ANALYSIS, MAGNETISM & MAXWELL'S EQUATIONS (Topics 11, 12 & 13)

Directions: Each of the questions or incomplete statements below is followed by five suggested answers or completions. Select the one that is best in each case and place the letter of your choice in the corresponding box on the student answer sheet.

Note: To simplify calculations, you may use $g = 10\,\mathrm{m/s^2}$ in all problems.

Questions 1 to 4



1. What is the current flowing through the circuit shown in the diagram?
   (A) 1 A
   (B) 2 A
   (C) 4 A
   (D) 6 A
   (E) 12 A

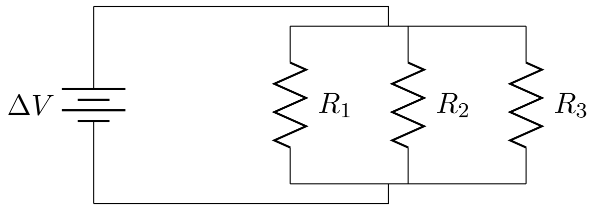
2. Which of the following statements is true about the circuit shown in the diagram?
   (A) The voltage drop is greatest across R_1, but R_1 has the least amount of current flowing through it.
   (B) The voltage drop is greatest across R_2, but R_2 has the least amount of current flowing through it.
   (C) The voltage drop is greatest across R_3, but R_3 has the least amount of current flowing through it.
   (D) The voltage drops and current are equal across all resistors.
   (E) The voltage drop is greatest across R_1, but the current is equal at all points in the circuit.

3. In this diagram, what is the power dissipated by all of the resistors in the circuit?
   (A) 2 W
   (B) 6 W
   (C) 12 W
   (D) 24 W
   (E) 48 W

4. In the diagram, what is the voltage drop across the third resistor (R_3)?
   (A) 2 V
   (B) 3 V
   (C) 4 V
   (D) 6 V
   (E) 12 V

5. Which of the following statements best summarizes a series circuit with three different resistances?
   (A) In all parts of the circuit, the resistances are different, the voltage drops are the same, and the current is different.
   (B) In all parts of the circuit, the resistances are the same, the voltage drops are the same, and the current is different.
   (C) In all parts of the circuit, the resistances are different, the voltage drops are different, and the current is the same.
   (D) In all parts of the circuit, the resistances are different, the voltage drops are the same, and the current is the same.
   (E) In all parts of the circuit, the resistances are the same, the voltage drops are the same, and the current is the same.

Questions 6-9



$\Delta V = 12.0\,\mathrm{V}$, $R_1 = 10.0\,\Omega$,
$R_2 = 6.0\,\Omega$, $R_3 = 8.0\,\Omega$

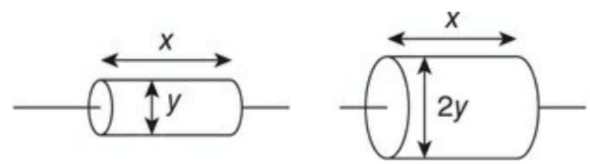
6. For the circuit in the diagram, which of the following expressions will describe the amount of current flowing through the resistors?
   (A) $I_1 = I_2 = I_3$
   (B) $I_3 > I_2 > I_1$
   (C) $I_1 > I_2 < I_3$
   (D) $I_2 > I_1 > I_3$
   (E) $I_1 < I_2 < I_3$

7. For the circuit in the diagram, what is the equivalent resistance?
   (A) $0.040\,\Omega$
   (B) $0.40\,\Omega$
   (C) $1.0\,\Omega$
   (D) $2.6\,\Omega$
   (E) $24\,\Omega$

8. For the circuit in the diagram, what is the total current?
   (A) 0.5 A
   (B) 4.6 A
   (C) 12 A
   (D) 30 A
   (E) 300 A

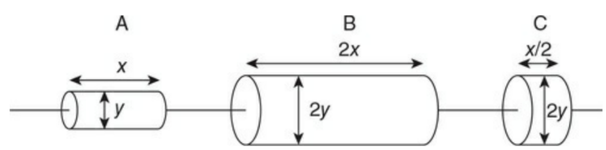
9. For the circuit in the diagram, the third resistor (R_3) dissipates how much energy each second?
   (A) 12 W
   (B) 14 W
   (C) 46 W
   (D) 212 W
   (E) 300 W

10. Two resistors made of the same material are shown in the figure. A current of I flows through the left resistor when connected to a potential difference of V. What current will flow through the right resistor when connected to the same potential?



   (A) $I/2$
   (B) $I/4$
   (C) I
   (D) $2I$
   (E) $4I$

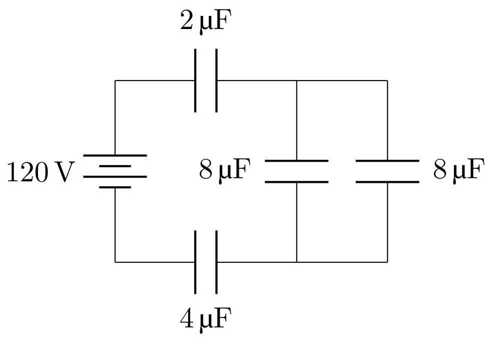
Questions 11 and 12



11. Which is the correct ranking of the currents for the resistors?
   (A) $I_A = I_B = I_C$
   (B) $I_A > I_B > I_C$
   (C) $I_C > I_A = I_B$
   (D) $I_C > I_B > I_A$
   (E) $I_C < I_B < I_A$

12. Which is the correct ranking of the potential differences of the resistors?
   (A) $V_A = V_B = V_C$
   (B) $V_A > V_B > V_C$
   (C) $V_A = V_B > V_C$
   (D) $V_C > V_B > V_A$
   (E) $V_C < V_B < V_A$

Questions 13-14



13. The equivalent capacitance of this circuit is

(A) 7/4 μF
(B) 4/7 μF
(C) 21/16 μF
(D) 10 μF
(E) 22 μF

14. The charge stored on the 2 μF capacitor is most nearly

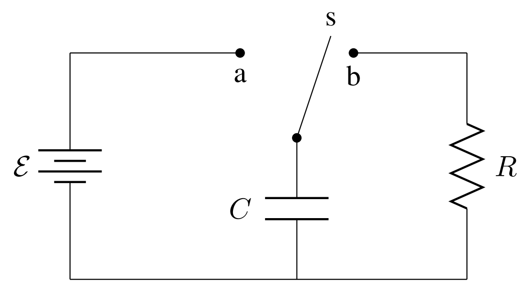
(A) 6 μC
(B) 12 μC
(C) 22 μC
(D) 36 μC
(E) 120 μC

15. A capacitor C_0 is connected to a battery and stores charge. If the space between the capacitor plates is filled with oil, which of the following quantities increase?

(A) Capacitance and voltage across the plates
(B) Charge and voltage across the plates
(C) Capacitance and electric field between the plates
(D) Capacitance and charge on the plates
(E) Electric field between the plates and voltage across the plates

Question 16–17

The circuit shows a capacitor, a battery, and a resistor. Switch S is first connected to point a to charge the capacitor, then a long time later switched to point b to discharge the capacitor through the resistor.



16. The time constant τ for discharging the capacitor through the resistor could be decreased (faster discharge) by

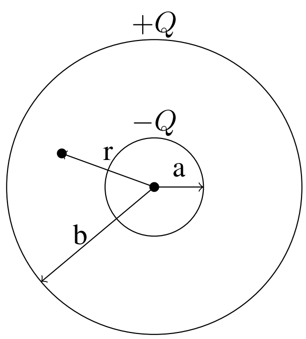
(A) placing another resistor in series with the first resistor
(B) placing another resistor in parallel with the first resistor
(C) placing another capacitor in parallel with the first capacitor
(D) placing another battery in series in the same direction with the first battery
(E) increasing both R and C

17. The maximum current through the resistor is

(A) $\mathcal{E}/2R$
(B) $\mathcal{E}/R$
(C) $\mathcal{E}/RC$
(D) $\mathcal{E}/2RC$
(E) $C\mathcal{E}/R$

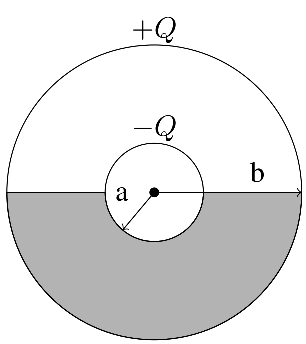
Questions 18–20

18. The spherical capacitor shown consists of a conducting shell of radius a inside a larger conducting shell of radius b. A charge Q is placed on the inner sphere and a charge $+Q$ is placed on the outer shell. The capacitance of the capacitor is C_0. The magnitude of the electric field E at a distance r between the spheres is



(A) $\dfrac{Q}{4\pi\epsilon_0 r^2}$
(B) $\dfrac{Q}{4\pi\epsilon_0 r}$
(C) $\dfrac{Q}{4\pi\epsilon_0 a^2}$
(D) $\dfrac{Q}{4\pi\epsilon_0 b^2}$
(E) zero

19. The bottom half of the space between the spheres is filled with oil of dielectric constant $\kappa = 3$, creating two capacitors connected to each other. Which of the following is true of the two capacitors?



(A) They are connected in series.
(B) They are connected in parallel.
(C) The total capacitance has not changed.
(D) The total capacitance of the spheres has decreased.
(E) The total capacitance is now zero.

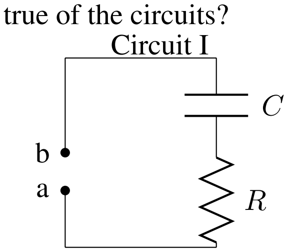
20. With the bottom half of the space between the spheres having been filled with oil of dielectric constant $\kappa = 3$, the new capacitance of the spheres is

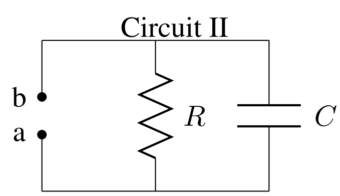
(A) zero
(B) C_0
(C) $2C_0$
(D) $3C_0$
(E) $4C_0$

21. A battery of voltage V_0 is attached to two parallel conducting plates. Charge is distributed on the plates, and then the battery is removed. A dielectric is then inserted between the plates, filling the space. Which of the following decreases after the battery is removed and the dielectric is inserted to fill the space between the plates?

(A) Capacitance
(B) Charge on the plates
(C) Net electric field between the plates
(D) Area of the plates
(E) Separation distance between the plates

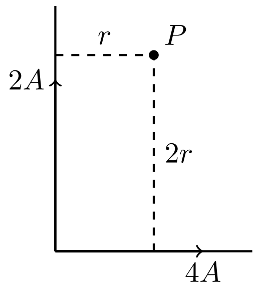
22. Circuit I and Circuit II shown each consist of a capacitor and a resistor. A battery is connected across a and b, and then removed. Which of the following statements is true of the circuits?





(A) Circuit I and Circuit II will both retain stored energy when the battery is removed.
(B) Neither Circuit I nor Circuit II will retain stored energy when the battery is removed.
(C) Only Circuit I will retain stored energy when the battery is removed.
(D) Only Circuit II will retain stored energy when the battery is removed.
(E) Current will continue to flow in both circuits after the battery is removed.

Questions 23–24
Two wires carry currents $2A$ and $4A$ in the directions shown. Point P is a distance r from the wire carrying $2A$, and a distance $2r$ from the wire carrying $4A$.



23. Which of the following statements is true?
    (A) The magnetic field produced at point P by the wire carrying $2A$ is greater than the magnetic field produced at point P by the wire carrying $4A$, but opposite in direction.
    (B) The magnetic field produced at point P by the wire carrying $2A$ is less than the magnetic field produced at point P by the wire carrying $4A$, and in the same direction.
    (C) The magnetic field produced at point P by the wire carrying $2A$ is equal to the magnetic field produced at point P by the wire carrying $4A$, but opposite in direction.
    (D) The magnetic field produced at point P by the wire carrying $2A$ is equal to the magnetic field produced at point P by the wire carrying $4A$, and in the same direction.
    (E) The magnetic field produced at point P by the wire carrying $2A$ is greater than the magnetic field produced at point P by the wire carrying $4A$, and in the same direction.

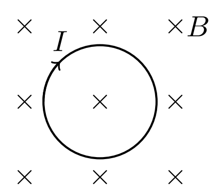
24. The magnitude of the resultant magnetic field at point P due to the current in the two wires is
    (A) zero
    (B) $\dfrac{\mu_0(2A)}{2\pi r}$
    (C) $\dfrac{\mu_0(2A)}{\pi r}$
    (D) $\dfrac{\mu_0(4A)}{2\pi r}$
    (E) $\dfrac{\mu_0(6A)}{4\pi r}$

Questions 25–26 Two wires are parallel to each other, one carrying twice the current as the other. The two currents flow in the same direction.

25. Which of the following is true of the forces the wires exert on each other?
    (A) The wire with the larger current exerts a greater force on the other wire.
    (B) The wire with the smaller current exerts a greater force on the other wire.
    (C) The wires exert equal and opposite forces on each other.
    (D) The wires exert equal forces on each other, but in the same direction.
    (E) The net force between the wires is zero.

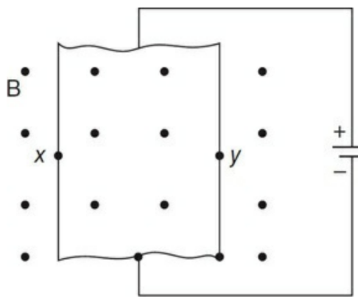
26. The direction of the force between the wires is
    (A) repulsive
    (B) attractive
    (C) zero
    (D) into the page
    (E) out of the page

27. A loop of wire in the plane of the page carries a clockwise current I and is placed in a magnetic field that is directed into the page as shown. Which of the following will happen as a result of the wire loop being in the magnetic field?



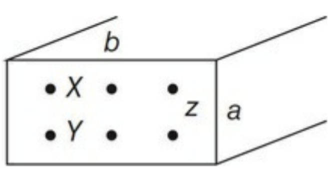
    (A) The wire loop will rotate clockwise.
    (B) The wire loop will rotate counterclockwise.
    (C) The wire loop will flip on a horizontal axis through its center.
    (D) The wire loop will expand in size.
    (E) The wire loop will contract in size.

28. A thin sheet of copper is placed in a uniform magnetic field. A battery is connected to the top and bottom ends of the copper sheet, so that conventional current flows from the top to the bottom of the sheet. Points X and Y are on the left and right sides of the sheet, respectively. Which of the following statements is true?



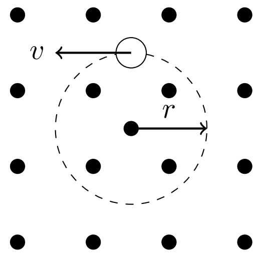
(A) Point X is at a higher potential than point Y.
(B) Point Y is at a higher potential than point X.
(C) Point X and point Y are at equal potential.
(D) Point X is at zero potential, and point Y has a positive potential.
(E) Point Y is at zero potential, and point X has a negative potential.

29. A very long conducting slab of copper of height a and width b carries a current I throughout its cross-sectional area. The current density j is constant throughout the slab, and is directed out of the page through the facing area of the slab. Points X and Y are marked on the facing area of the slab. The current density j can be expressed by the expression



(A) $\dfrac{I}{a^2}$
(B) $\dfrac{I}{b^2}$
(C) $\dfrac{I}{(ab)^2}$
(D) $\dfrac{I}{ab}$
(E) $\dfrac{I}{a+b}$

Questions 30–31 A negatively charged particle of mass m and charge q in a uniform magnetic field B travels in a circular path of radius r.



30. In terms of the other given quantities, the charge-to-mass ratio q/m of the particle is

(A) $\dfrac{Bv}{r}$
(B) $\dfrac{r}{Bv}$
(C) $\dfrac{rv}{B}$
(D) rvB
(E) $\dfrac{v}{rB}$

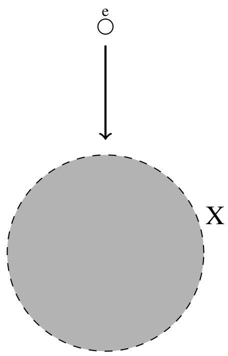
31. The work done by the magnetic field after two full revolutions of the charge is

(A) zero
(B) $-qvB/rm$
(C) qvm/Br
(D) $-mBr/qv$
(E) $-mqvBr$

32. A proton is moving toward the top of the page when it encounters a magnetic field that changes its direction of motion. After encountering the magnetic field, the proton's velocity vector is pointing out of the page. What is the direction of the magnetic field? Assume gravitational force is negligible.

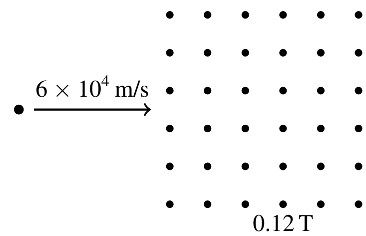
(A) Toward the bottom of the page
(B) To the right
(C) To the left
(D) Into the page

33. An electron is moving downward toward the bottom of the page when it passes through a region of magnetic field, as shown in the figure by the shaded area. The electron travels along a path that takes it through the spot marked X. The gravitational force on the electron is very small. What is the direction of the magnetic field?



(A) Toward the bottom of the page
(B) Toward the top of the page
(C) Out of the page
(D) Into the page

Questions 34–35



A proton is moving at a velocity of 6.0×10^4 m/s to the right, in the plane of the page, when it encounters a region of magnetic field with a magnitude 0.12 T perpendicular to the page, as shown in the figure.

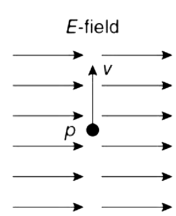
34. Which of the following is the radius of curvature of the path of the proton?

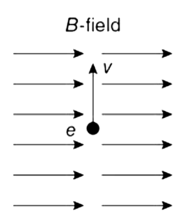
(A) 5×10^1 m
(B) 5×10^{-3} m
(C) 5×10^{-5} m
(D) 5×10^{-7} m

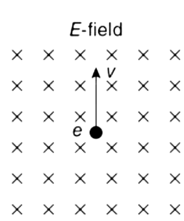
35. The proton is replaced with an electron moving in the same direction and at the same speed. Which of the following best describes the deflection direction and the radius of curvature of the electron in the magnetic field?

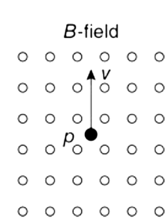
	Deflection direction	**Radius of curvature**
(A)	Same as proton	Larger than proton's
(B)	Same as proton	Smaller than proton's
(C)	Opposite of proton	Larger than proton's
(D)	Opposite of proton	Smaller than proton's

36. In each of the answer choices below, either a proton or an electron is moving toward the top of the page through either an electric or a magnetic field. In which case does the charged particle experience a force to the right? Select two answers.

(A)


(B)


(C)


(D)


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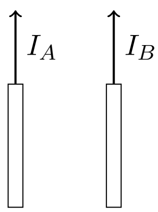
37. Two long parallel wires carry currents (I_A and I_B), as shown in the figure. Current I_A in the left wire is twice that of current I_B in the right wire. The magnetic force on the right wire is F. What is the magnetic force on the left wire in terms of F?

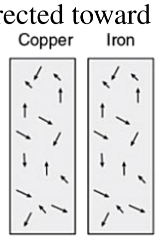


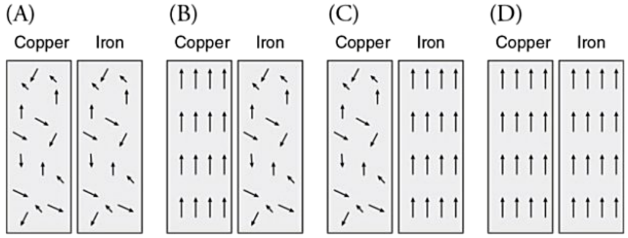
(A) F in the same direction
(B) F in the opposite direction
(C) $F/2$ in the same direction
(D) $F/2$ in the opposite direction

38. An iron magnet is broken in half at the midpoint between its north and south ends. What is the result?

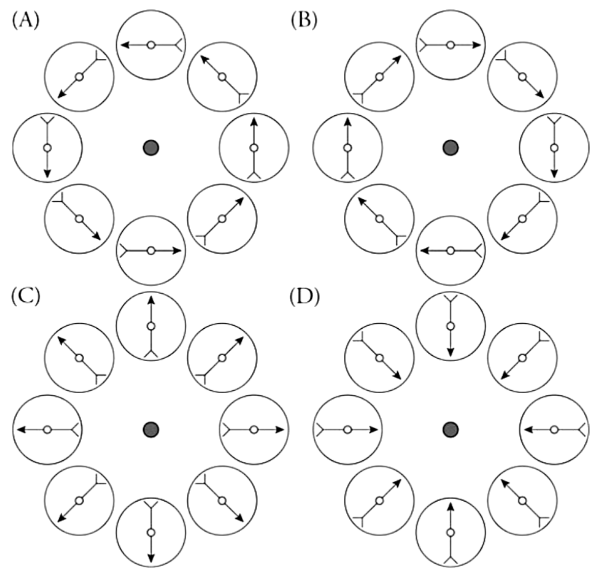
(A) A separate north pole and south pole, each with the same magnetic strength as the original magnet
(B) A separate north pole and south pole, each with half the magnetic strength of the original magnet
(C) Two separate north-south magnets, each with the same magnetic strength as the original magnet
(D) Two separate north-south magnets, each with half the magnetic strength of the original magnet

39. The figure shows the microscopic dipoles inside two metal objects. Copper is diamagnetic. Iron is ferromagnetic. Which of the following best depicts the microscopic internal dipole position when the objects are placed in a strong, external magnetic field directed toward the top of the page?

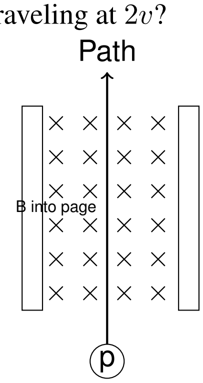




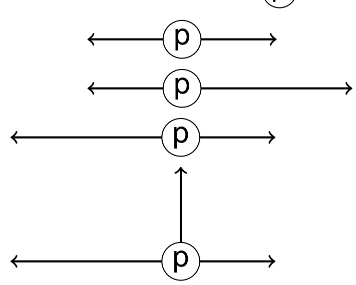
40. Compasses are arranged in a tight circle around a long wire that is perpendicular to the plane of the compasses. The wire is represented in the figures by a dot. The wire carries a large current directly into the page. Which of the following best depicts the orientation of the compass needles?



41. A magnetic field directed into the page, is placed between two charged capacitor plates as shown in the figure. The magnetic and electric fields are adjusted so a proton moving at a velocity of v will pass straight through the fields. The speed of the proton is doubled to $2v$. Which of the following force diagrams most accurately depicts the forces acting on the proton when traveling at $2v$?

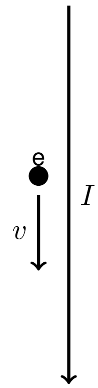


(A)
(B)
(C)
(D)



Questions 42–43

An electron is traveling at a constant speed of v parallel to a wire carrying a current of I, as shown in the figure. The electron is a distance of d from the wire.

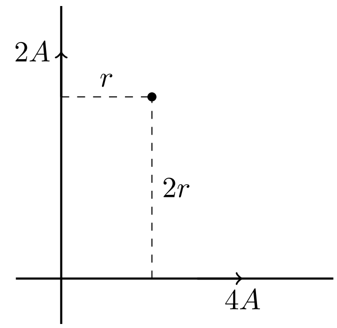


42. Which of the following is true concerning the force on the current- carrying wire due to the electron?
    - (A) The force is directed toward the right.
    - (B) The force is directed toward the left.
    - (C) The force is directed into the page.
    - (D) There is no force on the current-carrying wire due to the electron.

43. The force on the electron from the current is F. Which of the following will increase the force to $2F$? Select two answers.
    - (A) Halve the distance of the electron to the wire.
    - (B) Halve the velocity of the electron.
    - (C) Double the current in the wire.
    - (D) Double the current in the wire and halve the distance of the electron to the wire.

Questions 44–45

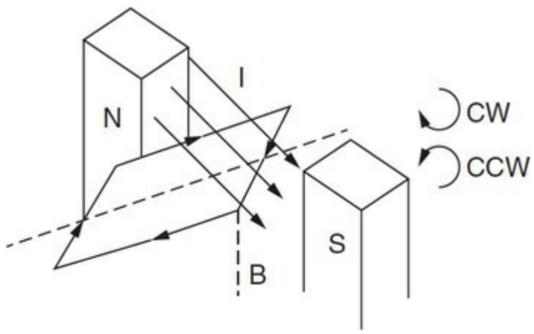
Two wires carry currents $2A$ and $4A$ in the directions shown. Point P is a distance r from the wire carrying $2A$, and a distance $2r$ from the wire carrying $4A$.



44. Which of the following statements is true?
    - (A) The magnetic field produced at point P by the wire carrying $2A$ is greater than the magnetic field produced at point P by the wire carrying $4A$, but opposite in direction.
    - (B) The magnetic field produced at point P by the wire carrying $2A$ is less than the magnetic field produced at point P by the wire carrying $4A$, and in the same direction.
    - (C) The magnetic field produced at point P by the wire carrying $2A$ is equal to the magnetic field produced at point P by the wire carrying $4A$, but opposite in direction.
    - (D) The magnetic field produced at point P by the wire carrying $2A$ is equal to the magnetic field produced at point P by the wire carrying $4A$, and in the same direction.
    - (E) The magnetic field produced at point P by the wire carrying $2A$ is greater than the magnetic field produced at point P by the wire carrying $4A$, and in the same direction.

45. The magnitude of the resultant magnetic field at point P due to the current in the two wires is
    - (A) zero
    - (B) $\dfrac{\mu_0(2A)}{2\pi r}$
    - (C) $\dfrac{\mu_0(2A)}{\pi r}$
    - (D) $\dfrac{\mu_0(4A)}{2\pi r}$
    - (E) $\dfrac{\mu_0(6A)}{4\pi r}$

46. An electric motor consists of a current-carrying loop of wire mounted to an axle and turned at a slight angle in a magnetic field as shown. The wire loop will



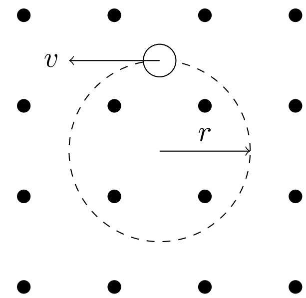
(A) experience a torque and turn clockwise
(B) experience a torque and turn counterclockwise
(C) accelerate upward out of the magnetic field
(D) accelerate downward out of the magnetic field
(E) not experience a force or torque

47. A current is passed through an analog ammeter and the needle moves to indicate the current flowing through the circuit. Which of the following best explains how an analog ammeter works?

(A) Current is passed through the needle placed in a magnetic field, and the needle is attracted to the high side of the scale.
(B) The needle is a magnet, and is attracted to a magnet on the high side of the scale.
(C) The needle gathers an electrostatic charge from the current, and is attracted to an electrostatic charge on the high side of the scale.
(D) Current is passed through a spring coil of wire placed in a magnetic field, and the coil rotates, moving the needle proportionally to the current in the coil.
(E) Current flows through the needle, making it heavier, and it falls to the high side of the scale.

Questions 48–49

A negatively charged particle of mass m and charge q in a uniform magnetic field B travels in a circular path of radius r.



48. In terms of the other given quantities, the charge-to-mass ratio q/m of the particle is

(A) $\frac{Bv}{r}$
(B) $\frac{r}{Bv}$
(C) $\frac{rv}{B}$
(D) rvB
(E) $\frac{v}{rB}$

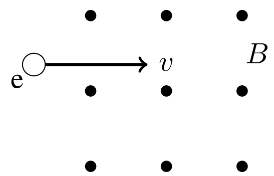
49. The work done by the magnetic field after two full revolutions of the charge is

(A) zero
(B) $-qvB/rm$
(C) qvm/Br
(D) $-mBr/qv$
(E) $-mqvBr$

50. A stationary compass placed above a charge moving with a speed v deflects its needle so that it aligns perpendicular to the velocity of the charge. If the compass also moves at the speed v along with the charge, the compass will

(A) deflect 90° relative to the velocity of the charge
(B) deflect 60° relative to the velocity of the charge
(C) deflect 45° relative to the velocity of the charge
(D) deflect 180° relative to the velocity of the charge
(E) not deflect

Questions 51–53
An electron enters a magnetic field that is directed out of the page as shown. The velocity of the electron is to the right.

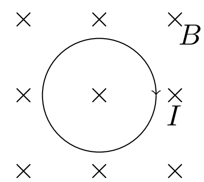


51. The force the magnetic field exerts on the electron when it enters the magnetic field is
    (A) directed into the page
    (B) directed out of the page
    (C) directed to the top of the page
    (D) directed to the bottom of the page
    (E) zero

52. The resulting path of the electron after entering the magnetic field is a
    (A) straight line
    (B) circle
    (C) spiral
    (D) parabola
    (E) hyperbola

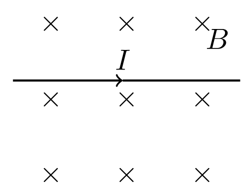
53. The work done by the magnetic field on the electron for one complete revolution at a radius r is
    (A) $qvBr$
    (B) qvB/r
    (C) qv/Br
    (D) Br/qv
    (E) zero

54. A loop of wire in the plane of the page carries a clockwise current I and is placed in a magnetic field that is directed into the page as shown. Which of the following will happen as a result of the wire loop being in the magnetic field?



    (A) The wire loop will rotate clockwise.
    (B) The wire loop will rotate counterclockwise.
    (C) The wire loop will flip on a horizontal axis through its center.
    (D) The wire loop will expand in size.
    (E) The wire loop will contract in size.

55. A wire in the plane of the page carries a current directed to the right as shown. The wire is placed in a magnetic field that is directed into the plane of the page. The force the magnetic field applies to the wire is

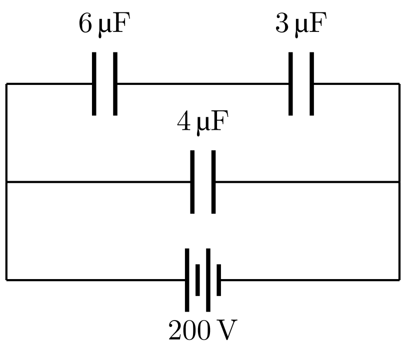


    (A) directed into the page
    (B) directed out of the page
    (C) directed to the top of the page
    (D) directed to the bottom of the page
    (E) zero

AP PHYSICS 1 & C: CIRCUIT ANALYSIS, MAGNETISM AND MAXWELL'S EQUATIONS
SECTION II
8 Questions

Directions: Answer all questions. The suggested time is about 10 minutes for answering each of the questions. The parts within a question may not have equal weight. All final numerical answers should include appropriate units. Credit depends on the quality of your solutions and explanations, so you should show your work. Credit also depends on demonstrating that you know which physical principles would be appropriate to apply in a particular situation. Therefore, you should clearly indicate which part of a question your work is for.

1. The circuit in the figure consists of three capacitors (3 μF, 4 μF, and 6 μF) connected to a 200 V battery.

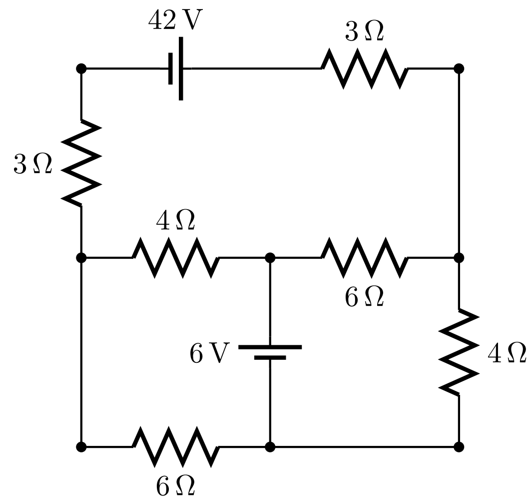


(a) Calculate the equivalent capacitance of the combined three capacitors.
(b) Calculate the total energy stored in the 6 μF and 3 μF capacitor combination.

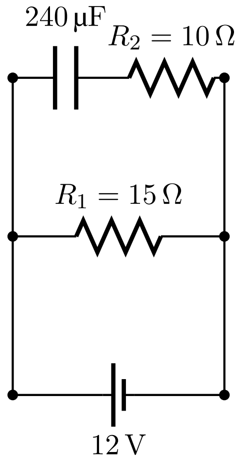
2. A 60 μF capacitor is charged to 12 V. The capacitor is then removed from the battery and the plate separation is increased from 2.0 mm to 3.5 mm.

(a) What is the charge on the capacitor?
(b) How much energy was originally stored in the capacitor?
(c) By how much is the energy increased when the plate separation is changed?

3. Find the current in each part of the circuit shown in the figure below.



4. The figure shows a circuit with two resistors, a battery, a capacitor, and a switch. Originally, the switch is open, and the capacitor is uncharged.



(a) Complete the voltage-current-resistance-power (VIRP) chart for the circuit immediately after the switch is closed.

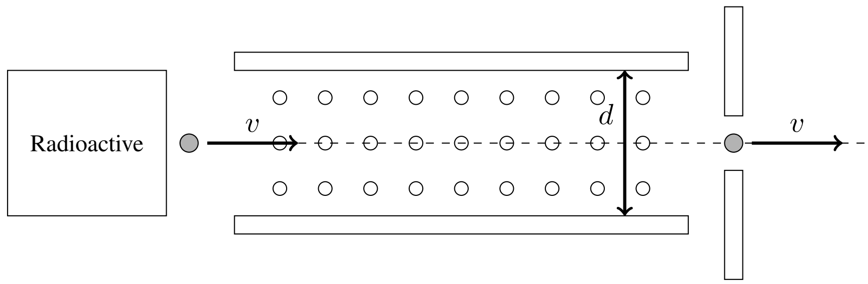
Location	***V***	***I***	***R***	***P***
1			$15\,\Omega$	
2			$10\,\Omega$	
Total for Circuit	12 V			

(b) Complete the voltage-current-resistance-power (VIRP) chart for the circuit after the switch is closed for a long time.

Location	***V***	***I***	***R***	***P***
1			$15\,\Omega$	
2			$10\,\Omega$	
Total for Circuit	12 V			

(c) What is the energy stored in the capacitor after the switch has been closed a long time?

5. A lead box containing radioactive materials that emit both electrons and positrons is placed near an apparatus consisting of an evacuated capacitor that is filled with a magnetic field, as shown in the figure. Electrons that enter along the center line of the capacitor plates travel straight through (undeflected) with a velocity of $v = 1.0 \times 10^7\,\mathrm{m/s}$ and out the hole in the center of the apparatus on the right. The capacitor plates are separated by a distance of $d = 0.020\,\mathrm{m}$; each plate has an area of $A = 1.0 \times 10^{-4}\,\mathrm{m}^2$ and a potential difference of ΔV. A uniform magnetic field of $B = 0.030\,\mathrm{T}$ is directed out of the page between the plates, as shown in the figure.



(a) Explain why it is acceptable to neglect the effects of gravity on the electrons passing through the apparatus.

(b) i. Explain why the electrons pass through the capacitor plates undeflected. Support your argument with an algebraic equation and an appropriately drawn force diagram.

ii. Use your equation to calculate the potential difference (ΔV) between the capacitor plates.

iii. Which capacitor plate has the highest potential? Justify your reasoning making reference to the electric field.

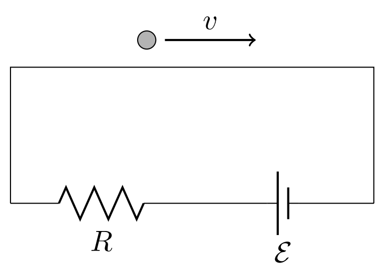
iv. Calculate the magnitude of the energy that is stored in the capacitor.

(c) A positron enters the apparatus along the same path as the electrons from part (b).

i. Explain why the positron, traveling at the same speed as the electrons, will also travel straight through the device undeflected. Support your argument with an equation.

ii. A second positron enters the apparatus at a speed of $2v$. Sketch the path of the positron through the capacitor plates on the figure.

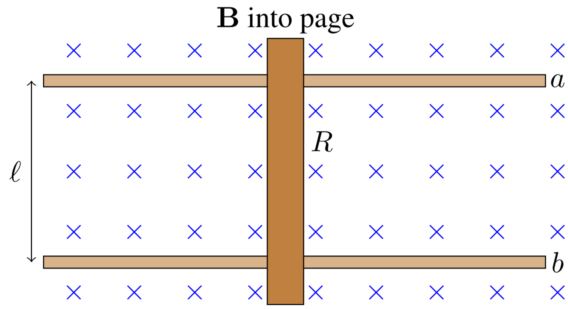
(d) An electron exits the apparatus at a velocity of $v = 1.0 \times 10^7\,\mathrm{m/s}$ parallel to a long wire of a circuit, as shown in the figure. The distance between the electron and the wire is 1 mm.



i. Calculate the potential difference-to-resistance ratio of the circuit such that the electron will experience a force F of 1.3×10^{-16} N.

ii. Draw a force vector on the figure to show the direction of the force on the electron.

Perform calculations for Question 1 here.

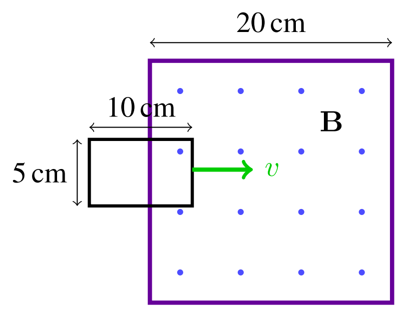


6. In the above figure, a rod has a resistance and the rails have negligible resistance. A battery of emf $\mathcal{E}$ and negligible internal resistance is connected between points a and b such that the current in the rod is downward. The rod is placed at rest aqt $t = 0$.

   (a) Find the force on the rod as a function of speed v.
   (b) Show that the rod reaches terminal velocity, and find the expression for it.
   (c) What is the current when the rod reaches its terminal velocity?

7. In the above figure, the rod has a resistance of R and the rails have negligible resistance. A capacitor with charge Q_0 and capacitance C is connected between points a and b such that the current in the road is downward. The rod is places at rest at $t = 0$.

   (a) Write the equation of motion for the rod on the rails.
   (b) Show that the terminal speed of the rod down the rail is related to the final charge on the capacitor.



8. A 10 cm by 5 cm rectangular loop with resistance 2.5 Ω is pulled through a region of uniform magnetic field $B = 1.7\,\mathrm{T}$ with constant speed $v = 2.4\,\mathrm{cm/s}$. The front of the loop enters the region of the magnetic field at time $t = 0$.

   (a) Find and graph the flux through the loop as a function of time.

   (b) Find and graph the included emf and the current in the loop as a function of time. Neglect any self inductance of the loop and extend your graph from $t = 0$ to $t = 16\,\mathrm{s}$.