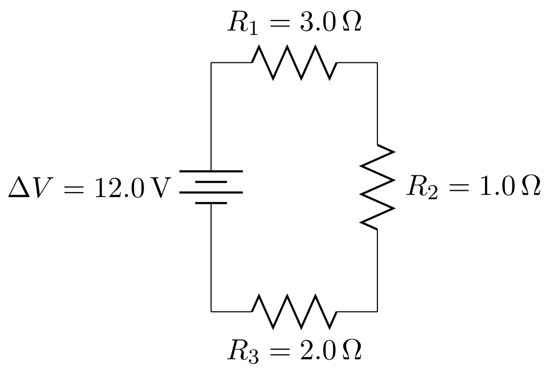
AP PHYSICS 2 & C: CIRCUIT ANALYSIS, MAGNETISM & MAXWELL'S EQUATIONS (Topics 11, 12 & 13)

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

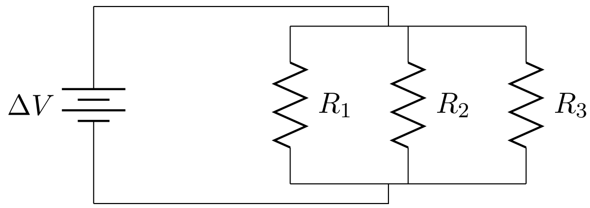
2. Which of the following statements is true about the circuit shown in the diagram?
   (A) The voltage drop is greatest across R_1, but R_1 has the least amount of current flowing through it.
   (B) The voltage drop is greatest across R_2, but R_2 has the least amount of current flowing through it.
   (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



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

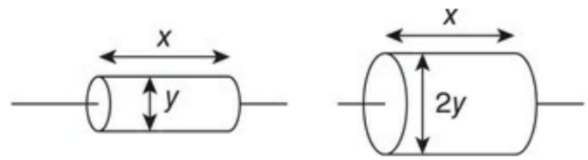
6. For the circuit in the diagram, which of the following expressions will describe the amount of current flowing through the resistors?
   (A) $I_1 = I_2 = I_3$
   (B) $I_3 > I_2 > I_1$
   (C) $I_1 > I_2 < I_3$
   (D) $I_2 > I_1 > I_3$
   (E) $I_1 < I_2 < I_3$

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

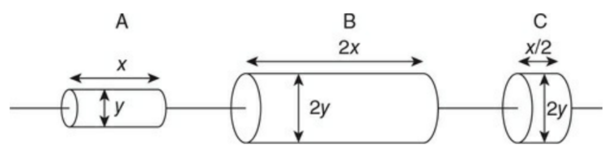
9. For the circuit in the diagram, the third resistor (R_3) dissipates how much energy each second?
   (A) 12 W
   (B) 14 W
   (C) 46 W
   (D) 212 W
   (E) 300 W

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) $4I$

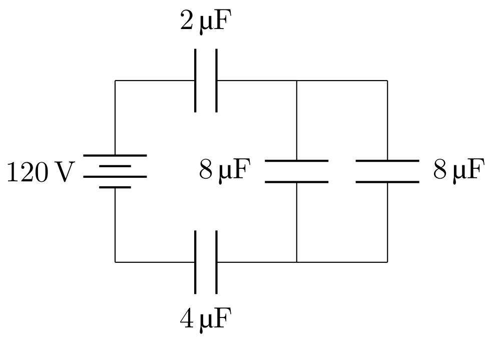
Questions 11 and 12



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

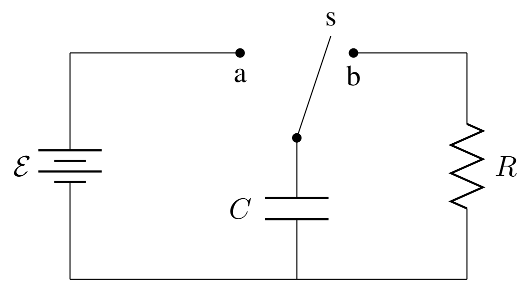


13. The equivalent capacitance of this circuit is
    - (A) 7/4 μF
    - (B) 4/7 μF
    - (C) 21/16 μF
    - (D) 10 μF
    - (E) 22 μF

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.

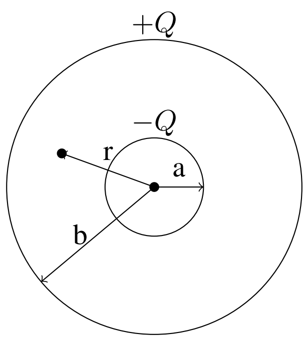


16. The time constant τ for discharging the capacitor through the resistor could be decreased (faster discharge) by
    - (A) placing another resistor in series with the first resistor
    - (B) placing another resistor in parallel with the first resistor
    - (C) placing another capacitor in parallel 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) $C\mathcal{E}/R$

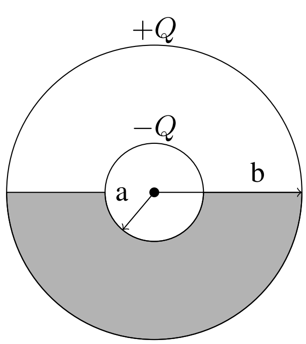
Questions 18–20

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) $\frac{Q}{4\pi\epsilon_0 r^2}$
(B) $\frac{Q}{4\pi\epsilon_0 r}$
(C) $\frac{Q}{4\pi\epsilon_0 a^2}$
(D) $\frac{Q}{4\pi\epsilon_0 b^2}$
(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

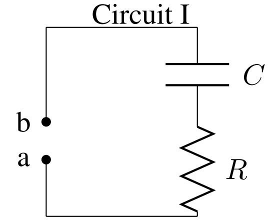
(A) zero
(B) C_0
(C) $2C_0$
(D) $3C_0$
(E) $4C_0$

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?

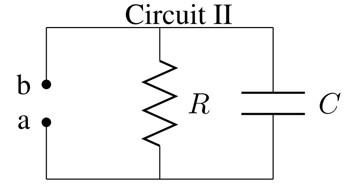
(A) Capacitance
(B) Charge on the plates
(C) Net electric field between the plates
(D) Area of the plates
(E) Separation distance between the plates

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?

Circuit I

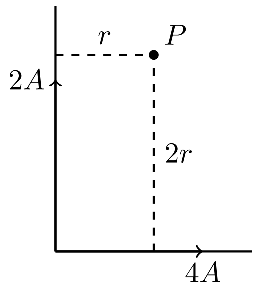


Circuit II



(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.

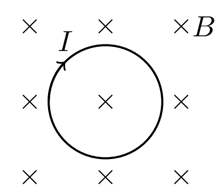
24. The magnitude of the resultant magnetic field at point P due to the current in the two wires is
    (A) zero
    (B) $\dfrac{\mu_0(2A)}{2\pi r}$
    (C) $\dfrac{\mu_0(2A)}{\pi r}$
    (D) $\dfrac{\mu_0(4A)}{2\pi r}$
    (E) $\dfrac{\mu_0(6A)}{4\pi r}$

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.

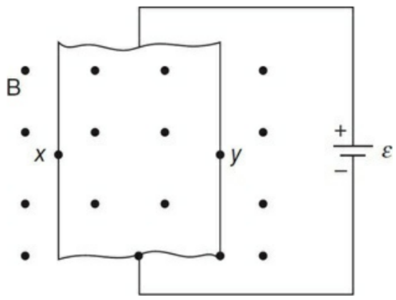
26. The direction of the force between the wires is
    (A) repulsive
    (B) attractive
    (C) zero
    (D) into the page
    (E) out of the page

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?



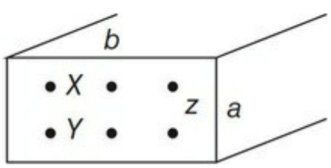
    (A) The wire loop will rotate clockwise.
    (B) The wire loop will rotate counterclockwise.
    (C) The wire loop will flip on a horizontal axis through its center.
    (D) The wire loop will expand in size.
    (E) The wire loop will contract in size.

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?



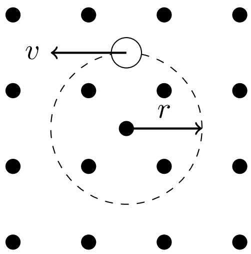
(A) Point X is at a higher potential than point Y.
(B) Point Y is at a higher potential than point X.
(C) Point X and point Y are at equal potential.
(D) Point X is at zero potential, and point Y has a positive potential.
(E) Point Y is at zero potential, and point X has a negative potential.

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) $\dfrac{v}{rB}$

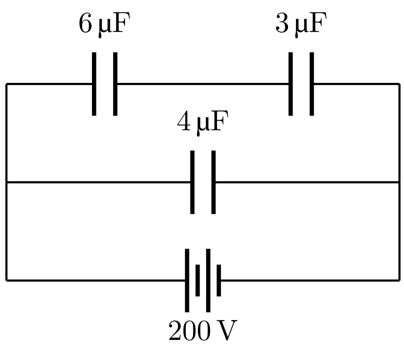
31. The work done by the magnetic field after two full revolutions of the charge is

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

AP PHYSICS 1 & C: CIRCUIT ANALYSIS, MAGNETISM AND MAXWELL'S EQUATIONS
SECTION II
4 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.

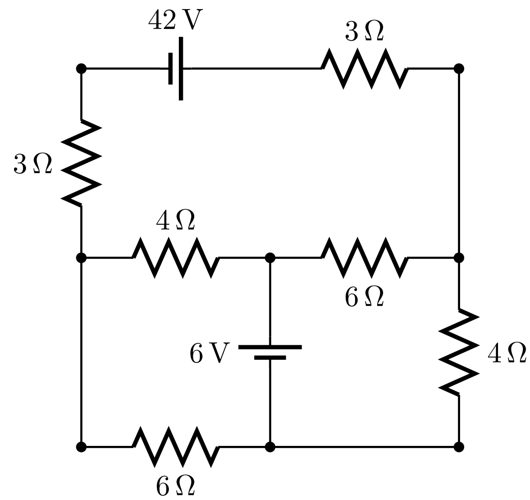


(a) Calculate the equivalent capacitance of the combined three capacitors.
(b) Calculate the total energy stored in the 6 μF and 3 μF capacitor combination.

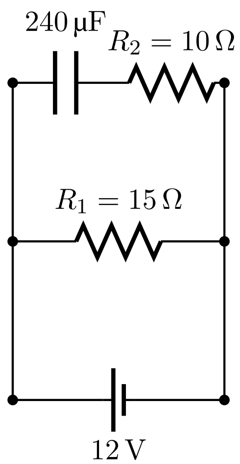
2. A 60 μF capacitor is charged to 12 V. The capacitor is then removed from the battery and the plate separation is increased from 2.0 mm to 3.5 mm.

(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?