Student #: _____ Student Name: _____

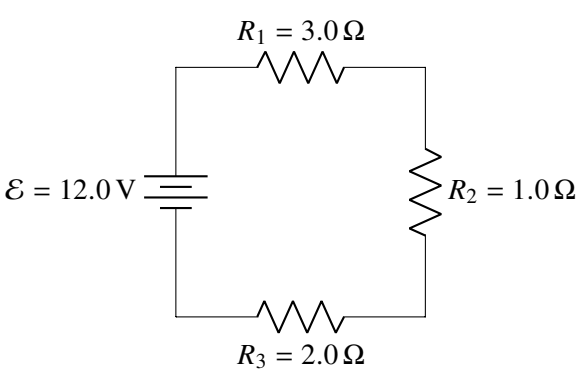
AP PHYSICS 1 & 2: DC CIRCUIT ANALYSIS

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 $g = 10\,\text{m/s}^2$ in all problems.

1. 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 2–5



2. 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

3. 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.

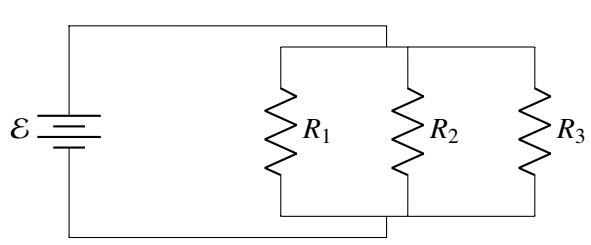
4. In this diagram, what is the power dissipated by all of the resistors in the circuit?
   (A) 2 W
   (B) 6 W
   (C) 12 W
   (D) 24 W
   (E) 48 W

5. 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

6. Two identical resistors with resistance R are connected in series with a power supply with a potential difference of ΔV. Which expression represents the power output of the entire circuit?
   (A) $\dfrac{\Delta V^2}{4R}$
   (B) $\dfrac{\Delta V^2}{2R}$
   (C) $\dfrac{\Delta V^2}{R}$
   (D) $\dfrac{2(\Delta V)^2}{R}$
   (E) $2R(\Delta V)^2$

7. Two identical resistors with resistance R are connected in parallel with a power supply with a potential difference of ΔV. Which expression represents the rate that the circuit transfers energy to a single resistor?
   (A) $\dfrac{\Delta V^2}{4R}$
   (B) $\dfrac{\Delta V^2}{2R}$
   (C) $\dfrac{\Delta V^2}{R}$
   (D) $\dfrac{2(\Delta V)^2}{R}$
   (E) $2R(\Delta V)^2$

Questions 8–11



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

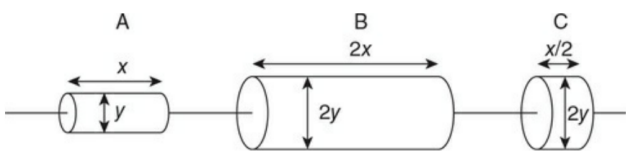
8. For the circuit in the diagram, which of the following expressions will describe the amount of current flowing through the resistors?
   (A) $I_1 = I_2 = I_3$
   (B) $I_3 > I_2 > I_1$
   (C) $I_1 > I_2 < I_3$
   (D) $I_2 > I_1 > I_3$
   (E) $I_1 < I_2 < I_3$

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

10. 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

11. 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

Questions 12–13



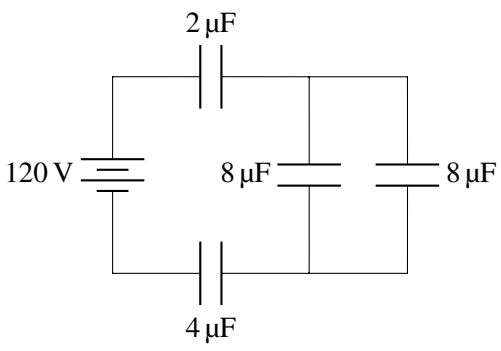
12. Which is the correct ranking of the currents for the resistors?

(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) $I_C < I_B < I_A$

13. 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 14–15



14. 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

15. 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

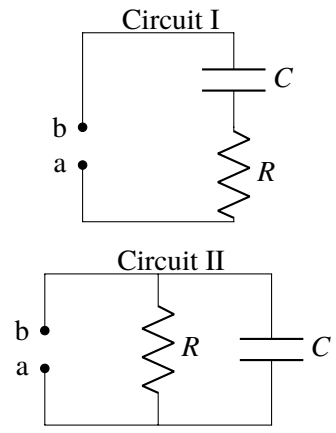
16. A capacitor C_0 is connected to a battery and stores charge. If the space between the capacitor plates is filled with oil, which of the following quantities increase?

(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

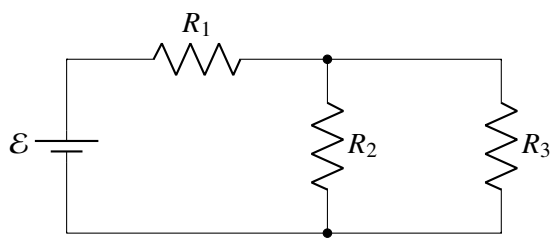
17. A battery of voltage V_0 is attached to two parallel conducting plates. Charge is distributed on the plates, and then the battery is removed. A dielectric is then inserted between the plates, filling the space. Which of the following decreases after the battery is removed and the dielectric is inserted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

18. 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.

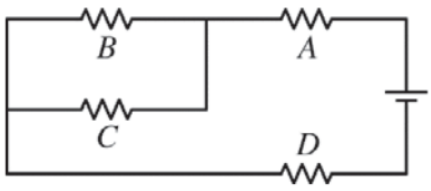


19. A simple circuit consisting of three resisotrs is shown above. R_1 had the same resistance as R_2, and R_2 has twice the resistance of R_3. Determine the ratio of the heat dissipated of R_1 to R_2.

(A) 1 : 9
(B) 1 : 3
(C) 1 : 1
(D) 3 : 1
(E) 9 : 1

AP PHYSICS 1 & 2: DC CIRCUIT ANALYSIS
SECTION II
5 Questions

Directions: Answer all 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.

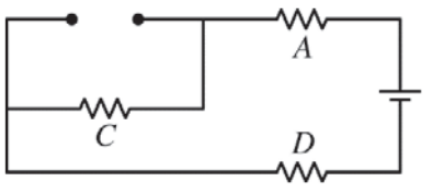


1. A circuit contains a battery and four identical resistors arranged as shown in the diagram above.
   (a) Rank the magnitude of the potential difference across each resistor from greatest to least. If any resistors have potential differences with the same magnitude, state that explicitly. Briefly explain your reasoning.

   Ranking:

   Brief explanation:

   Resistor *B* is now removed from the circuit, and there is no connection between the wires that were attached to it. The new circuit diagram is shown below.

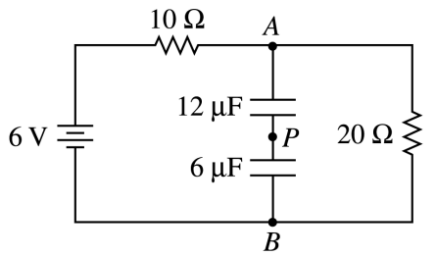


   (b) When resistor *B* is removed, does the current through resistor *A* increase, decrease, or remain the same? Explain your reasoning.

   ____ Increase ____ Decrease ____ Remain the same

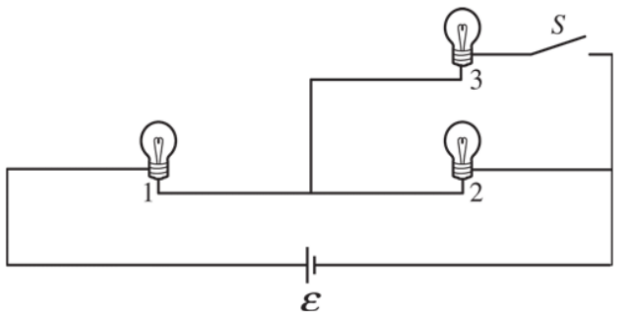
   (c) When resistor *B* is removed, does the current through resistor *C* increase, decrease, or remain the same? Briefly explain your reasoning.

   ____ Increase ____ Decrease ____ Remain the same



2. A circuit contains two resistors (10 Ω and 20 Ω) and two capacitors (12 μF and 6 μF) connected to a 6 V battery, as shown in the diagram above. The circuit has been connected for a long time.
   (a) Calculate the total capacitance of the circuit.
   (b) Calculate the current in the 10 Ω resistor.
   (c) Calculate the potential difference between points *A* and *B*.
   (d) Calculate the charge stored on one plate of the 6 μF capacitor.
   (e) The wire is cut at point *P*. Will the potential difference between points *A* and *B* increase, decrease, or remain the same? Justify your answer.

   _____ increase _____ decrease _____ remain the same



3. A battery of emf $\mathcal{E}$ and negligible internal resistance, three identical incandescent lightbulbs, and a switch S that is initially open are connected in the circuit shown above. The bulbs each have resistance R. Students make predictions about what happens to the brightness of the bulbs after the switch is closed.

   (a) A student makes the following prediction about bulb 1: "Bulb 1 will decrease in brightness when the switch is closed."

      i. Do you agree or disagree with the student's prediction about bulb 1? Qualitatively explain your reasoning.

      ii. Before the switch is closed, the power expended by bulb 1 is P_1. Derive an expression for the power P_{new} expended by bulb 1 after the switch is closed in terms of P_1.

      iii. How does the result of your derivation in part (a)ii relate to your explanation in part (a)i?

   (b) A student makes the following prediction about bulb 2: "Bulb 2 will decrease in brightness after the switch is closed."

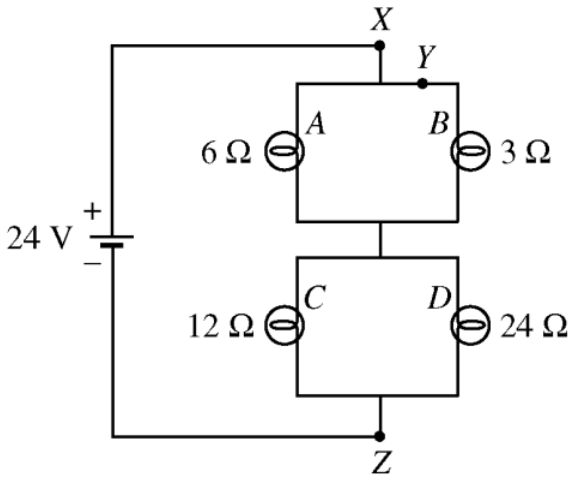
      i. Do you agree or disagree with the student's prediction about bulb 2? Explain your reasoning in words.

      ii. Justify your explanation with a calculation.

   (c) While the switch is open, bulb 3 is replaced with an uncharged capacitor. The switch is then closed.

      i. How does the brightness of bulb 1 compare to the brightness of bulb 2 immediately after the switch is closed? Justify your answer.

      ii. How does the brightness of bulb 1 compare to the brightness of bulb 2 a long time after the switch is closed? Justify your answer.



4. Four lightbulbs are connected in a circuit with a 24 V battery as shown above.

(a) i. Determine the average potential energy change of an electron as it moves from point Z to point X.

ii. Indicate whether the electron gains or loses potential energy as it moves from point Z to point X.

_____ Gains energy _____ Loses energy

(b) Calculate the equivalent resistance of the circuit.

(c) i. Calculate the magnitude of the current through point Y.

ii. Indicate on the diagram the direction of the current through point Y.

(d) Calculate the energy dissipated in the 12 W bulb in 5 s.

(e) Rank the bulbs in order of brightness, with 1 being the brightest. If any bulbs have the same brightness, give them the same ranking.

_____ Bulb A _____ Bulb B _____ Bulb C _____ Bulb D