Tutorial 8

Direct Current Circuits

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Lecture Outline

- **Chapter 27**, D Halliday, R Resnick, and J Walker, "Fundamentals of Physics" 9th Edition, Wiley (2005).

- Circuits
  - Pumping Charges: *electromotive force* (emf)
  - Single-Loop circuit
  - Multi-Loop circuits
  - Power in electric circuits
  - RC circuits

Lecture 08 Review

- Electromotive force (emf) is a device that produces a steady flow of charge between a pair of terminals through a circuit.
- Electric generator, battery, solar cells and fuel cells are all emf devices that produce the steady flow of charges by maintaining a potential difference between a pair of terminals.
- An **ideal emf device** is one that has no internal resistance to the internal movement of charge from terminal to terminal.
- A **real emf device,** such as any real battery, has internal resistance to the internal movement of charge. When a real emf device is not connected to a circuit, and thus does not have current through it, the potential difference between its terminals is equal to its emf. However, when that device has current through it, the potential difference between its terminals $V <$ emf.

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Lecture 08 Review

- We define the "emf" of the emf device in terms of this work:

$$\mathscr{E} = \frac{dW}{dq} \qquad \text{(definition of } \mathscr{E}\text{)}.$$

- The amount of work *dW* on the charge *dq* to force it to move from the lower potential terminal to the higher potential terminal.
- For a single-loop circuit with an emf connected to a certain amount of resistance, the current passing through the loop is simply the ratio between the emf and the resistance.

$$i = \frac{\mathscr{E}}{R}.$$

- We can also calculate the current in a single-loop circuit using the potential method, where we sum up the potential drop and gain over the closed circuit and equate that to zero.

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Lecture 08 Review

- To identify the potential drop or gain at each circuit component, we can follow the following two rules:

RESISTANCE RULE: For a move through a resistance in the direction of the current, the change in potential is $-iR$; in the opposite direction it is $+iR$.

EMF RULE: For a move through an ideal emf device in the direction of the emf arrow, the change in potential is $+\mathscr{E}$; in the opposite direction it is $-\mathscr{E}$.

- For the real emf devices, we need to account for the internal resistance in the analysis.
- When a potential difference V is applied across resistances connected in series, all the resistances experience the same current i. The sum of the potential differences across all the resistances is equal to the applied potential difference V.

Lecture 08 Review

- To find the potential between any two points in a circuit, we starts from one point and sum up the potential drop and gain of each elements to the other point. We can choose any path that is connected the two points. The result will be identical.
- Grounding a circuit means to define a zero potential point within the circuit. The point of that circuit is supposedly to be connected to the earth's surface, so the grounds of all circuits have the same potential.
- We are provided the expressions of power, potential and emf in a circuit.
- The Kirchhoff's junction rule specifies that the sum of the currents entering any junction must be equal to the sum of the currents leaving that junction. It is a very useful method for solving multi-loop circuits.

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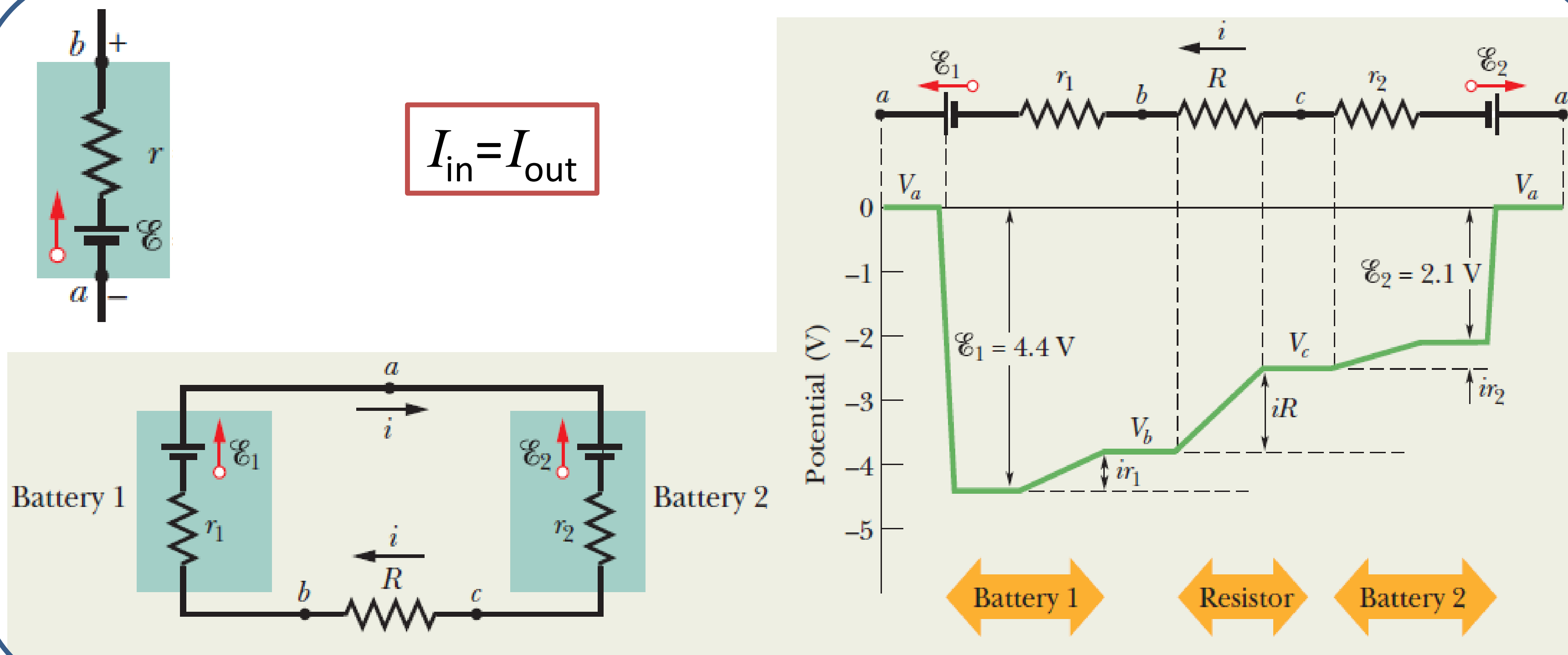
Lecture 08 Review

- To find the potential between any two points in a circuit, we starts from one point and sum up the potential drop and gain of each elements to the other point. We choose all *independent* paths to obtain the necessary number of equations.

$$I_{in}=I_{out}$$



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Halliday/Resnick/Walker
Fundamentals of Physics 8th edition

Classroom Response System Questions

Chapter 27 Circuits

Interactive Lecture Questions

PHY 1202

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27.3.1. In physics lab, two students measured the potential difference between the terminals of a battery and the current in a circuit connected to the battery. The students then made a graph of the two parameters as shown. They then drew a best fit line through the data. From their results, determine the approximate internal resistance of the battery.

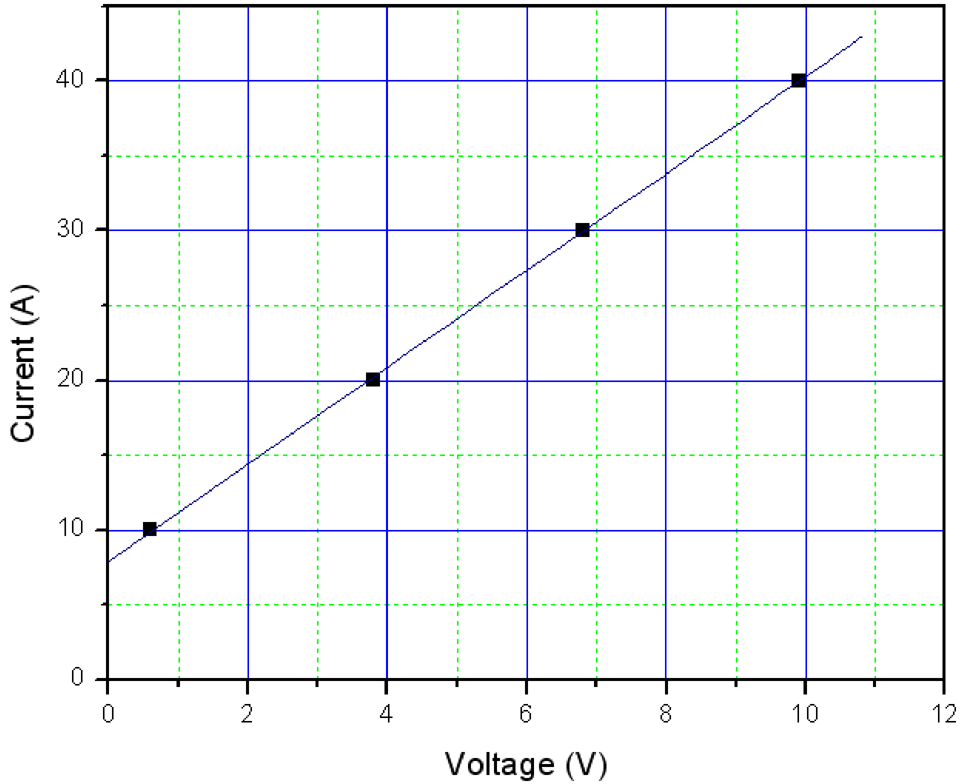
a) 0.002 Ω

b) 0.08 Ω

c) 0.1 Ω

d) 0.3 Ω

e) 0.6 Ω



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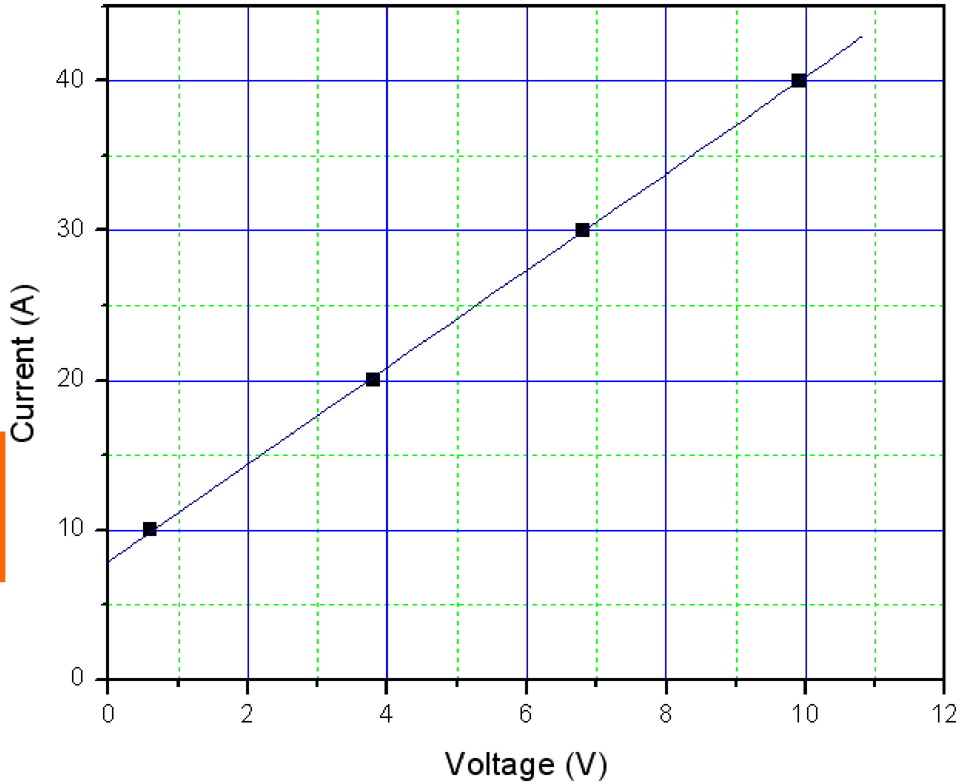

27.4.1. Consider a circuit that contains an ideal battery and a resistor to form a complete circuit. Which one of the following statements concerning the work done by the battery is true?

a) No work is done by the battery in such a circuit.

b) The work done is equal to the thermal energy dissipated by the resistor.

c) The work done is equal to the work needed to move a single charge from one side of the battery to the other.

d) The work done is equal to the emf of the battery.

e) The work done is equal to the product of the current flowing through the circuit and the resistor.

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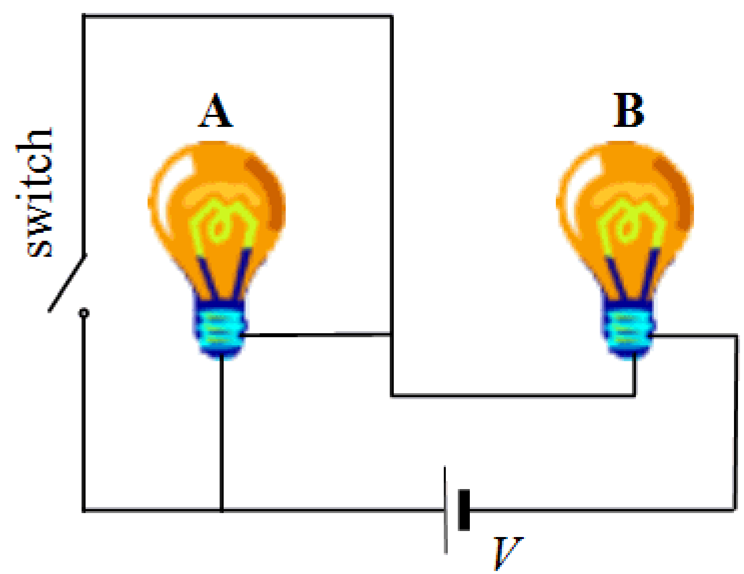
27.5.2. Consider the circuit shown in the drawing. Two identical light bulbs, labeled A and B, are connected in series with a battery and are illuminated equally. There is a switch in the circuit that is initially open. Which one of the following statements concerning the two bulbs is true after the switch is closed?

a) Bulbs A and B will be off.

b) Bulbs A and B will be equally illuminated.

c) Bulb A will be brighter and bulb B will be off.

d) Bulb A will be off and bulb B will be brighter.



e) Both bulbs will be dimmer than before the switch was closed.

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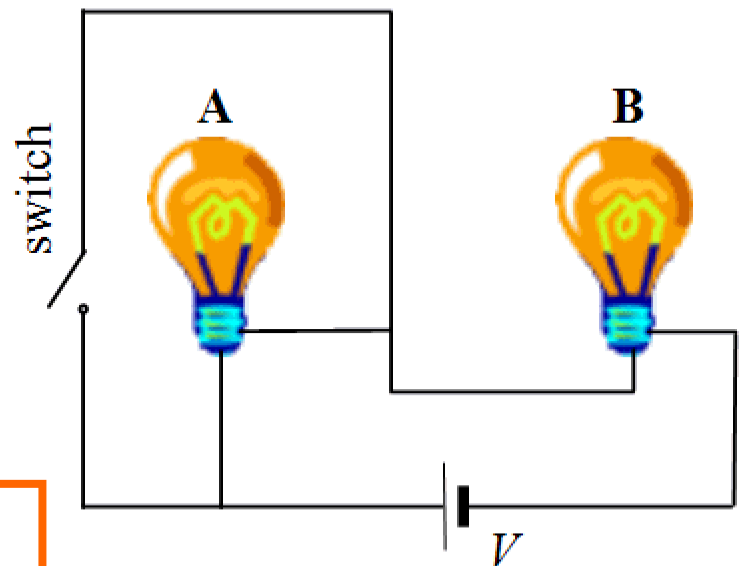

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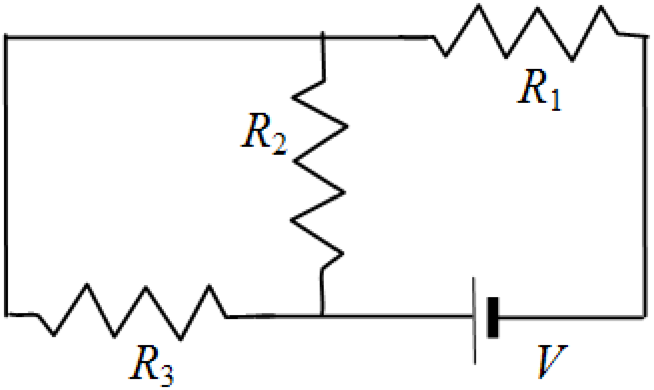
27.5.3. Consider the three resistors and the battery in the circuit shown. Which resistors, if any, are connected in series?



a) R_1 and R_2

b) R_1 and R_3

c) R_2 and R_3

d) R_1 and R_2 and R_3

e) No resistors are connected in series.

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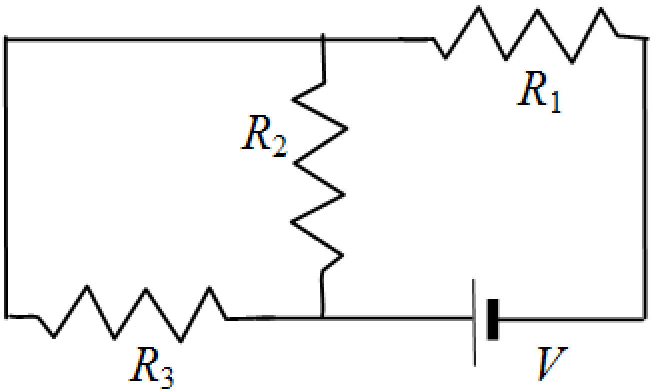

a) R_1 and R_2

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d) R_1 and R_2 and R_3

e) No resistors are connected in series.

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27.5.4. Consider the circuit shown. If the ideal emf in the circuit is 24 V and the three resistances are $R1 = 2.5\ \Omega$, $R2 = 4.0\ \Omega$, and $R3 = 6.0\ \Omega$, determine the current in the $4.0\ \Omega$ resistor.

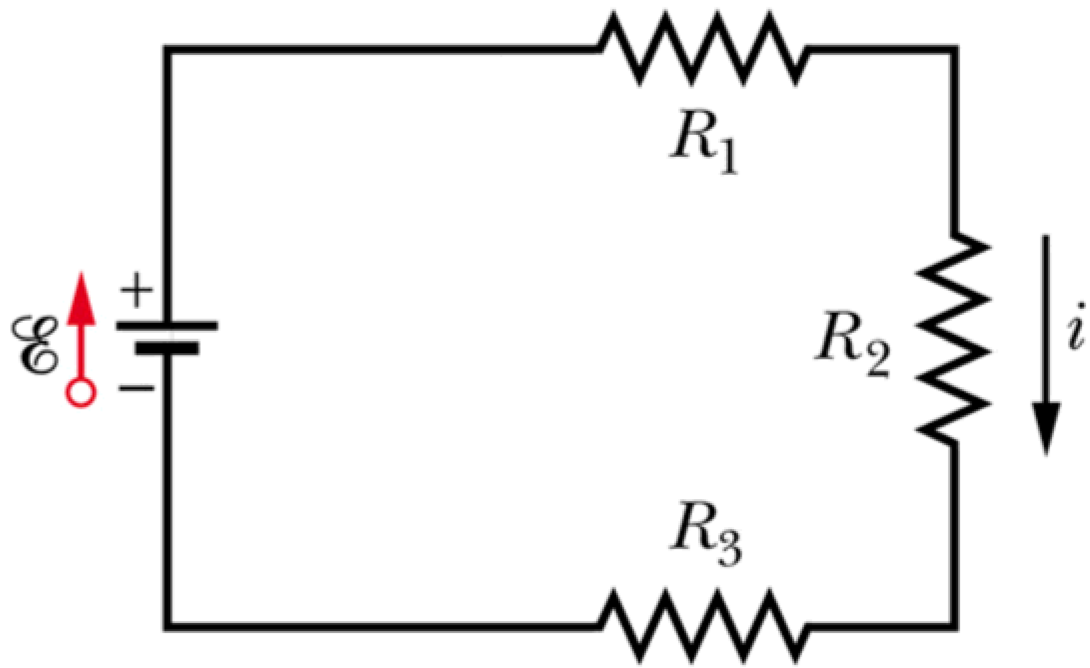
a) 1.2 A

b) 1.9 A

c) 4.0 A

d) 6.0 A

e) 6.5 A



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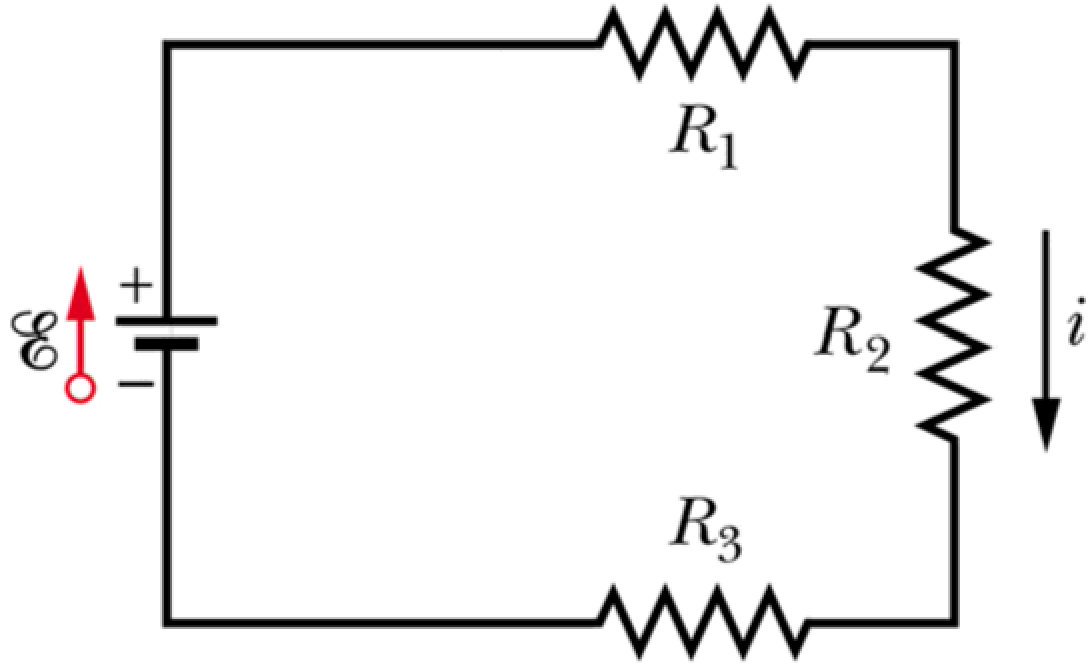

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27.7.2. Consider the three resistors and the battery in the circuit shown. Which resistors, if any, are connected in parallel?

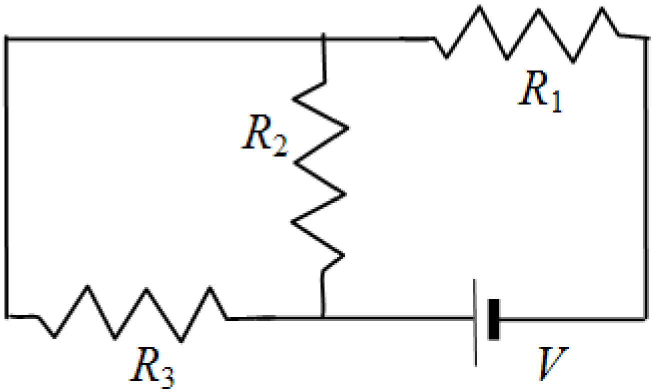
a) R_1 and R_2

b) R_1 and R_3

c) R_2 and R_3

d) R_1 and R_2 and R_3

e) No resistors are connected in parallel.



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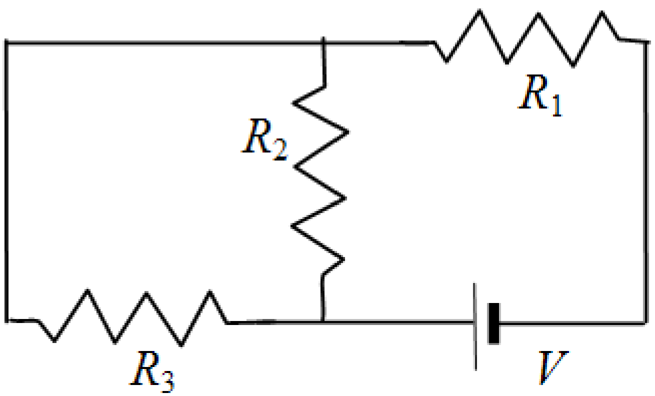
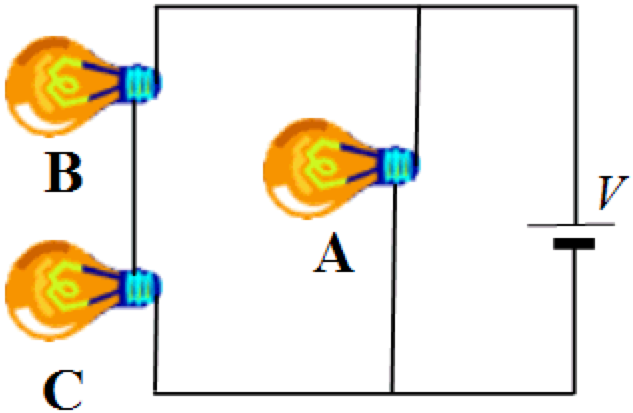


27.7.5. Consider the three identical light bulbs shown in the circuit. Bulbs B and C are wired in series with each other and are wired in parallel with bulb A. When the bulbs are connected to the battery as shown, how does the brightness of each bulb compare to the others?



a) Bulbs B and C are equally bright, but bulb A is less bright.

b) Bulbs B and C are equally bright, but less bright than bulb A.

c) All three bulbs are equally bright.

d) Bulbs A and B are equally bright, but bulb C is less bright.

e) Only bulb A is illuminated.

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$P=IV=I^2R=V^2/R$

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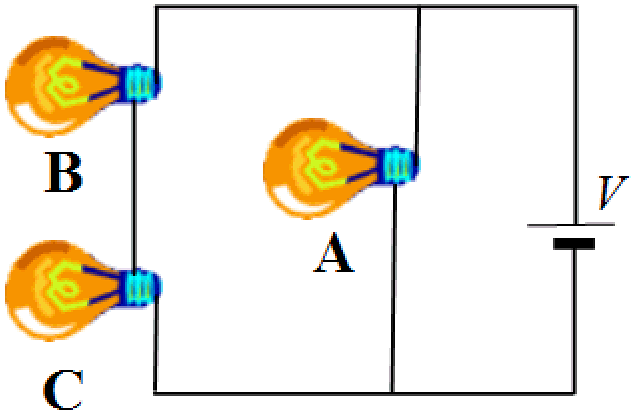


b) Bulbs B and C are equally bright, but less bright than bulb A.

c) All three bulbs are equally bright.

d) Bulbs A and B are equally bright, but bulb C is less bright.

e) Only bulb A is illuminated.

27.7.7. What is the approximate equivalent resistance of the five resistors shown in the circuit?

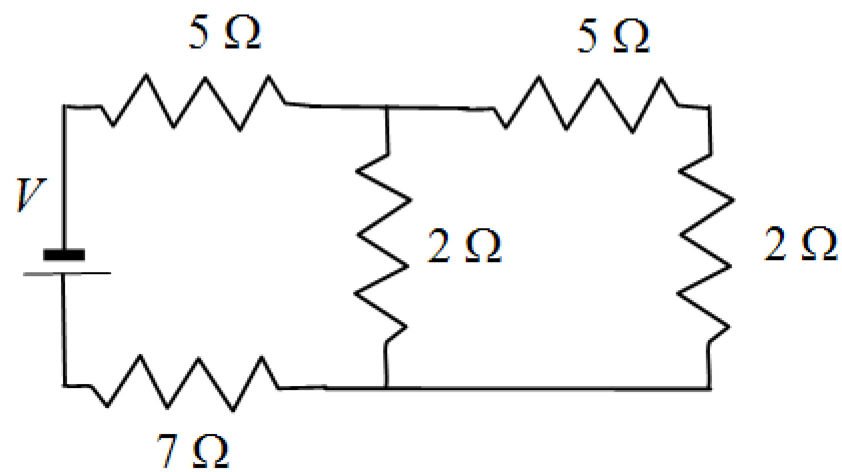
a) 21 Ω

b) 7 Ω

c) 11 Ω

d) 14 Ω

e) 19 Ω



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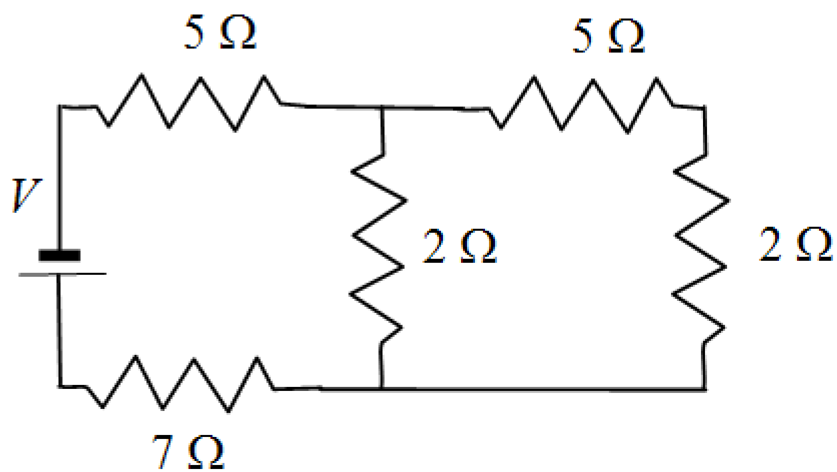

27.9.1. What effect, if any, does increasing the battery emf in an RC circuit have on the time to charge the capacitor?

a) The charging time will decrease because the rate of charge flowing to the plates will increase.

b) The charging time will decrease because the rate of charge flowing to the plates will decrease.

c) The charging time will not change because the charging time does not depend on the battery emf.

d) The charging time will increase because the emf is increased.

e) The charging time will decrease because potential difference across the plates will be larger.

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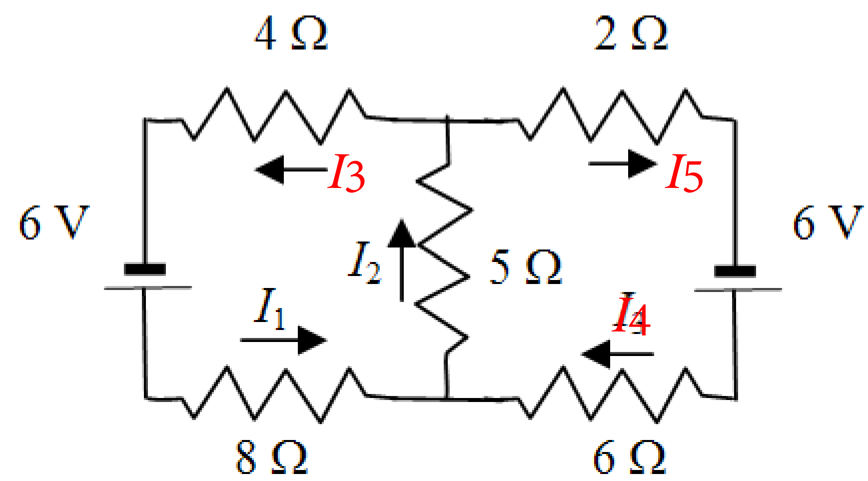
27.7.10. Which one of the following equations is not correct relative to the other four equations determined by applying Kirchoff's Rules to the circuit shown?



a) $I_2 = I_1 + I_4$

b) $I_2 = I_3 + I_5$

c) $6\text{ V} - (8\ \Omega)\, I_1 - (5\ \Omega)\, I_2 - (4\ \Omega)\, I_3 = 0$

d) $6\text{ V} - (6\ \Omega)\, I_4 - (5\ \Omega)\, I_2 - (2\ \Omega)\, I_5 = 0$

e) $6\text{ V} - (8\ \Omega)\, I_1 - (6\ \Omega)\, I_4 - 6\text{ V} - (2\ \Omega)\, I_5 - (4\ \Omega)\, I_3 = 0$

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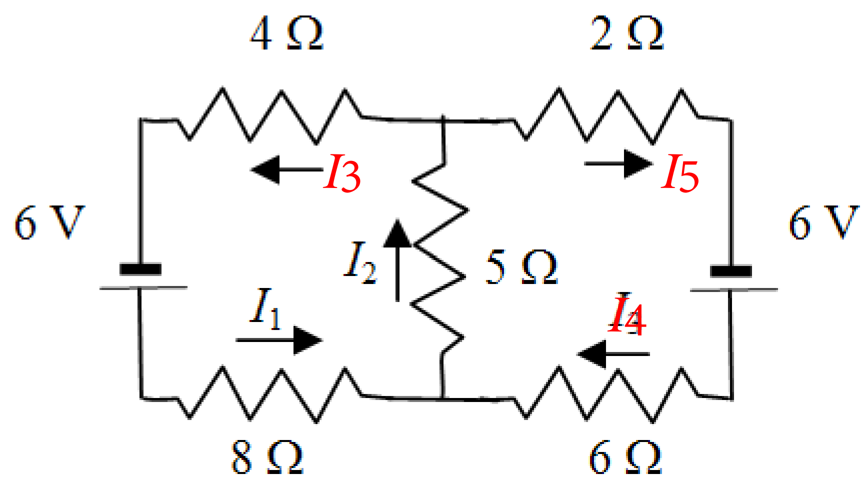

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