12 General Physics 2023/24

English Version

Chapter 4

Series and Parallel Circuits





Scan for Solution

or visit www.manasra.academy

Done by Alaa Al Faqeh

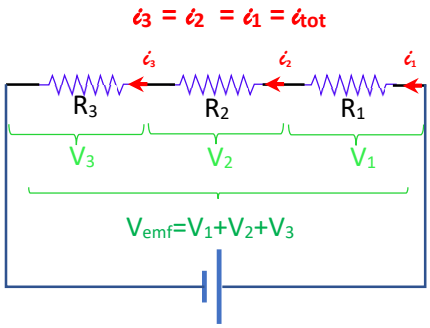


Manasra Academy

CHAPTER 4: Series and Parallel Circuits

SECTION 1: Simple Circuits

(Resistors in Series):



- Connection as shown in figure.

-All resistors in series group have the same current;

$$i_1 = i_2 = i_3 = \cdots \ldots . = i_{tot}$$

-The electric potential of each resistor is directly proportional to its resistance; $\Delta V \propto R$

-The total potential equals the sum of the individual potentials;

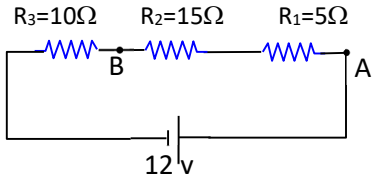
$$\Delta V_{tot(seriesgroup)} = \Delta V_1 + \Delta V_2 + \Delta V_3 + \cdots \ldots \ldots$$

-The equivalent resistance equals the sum of the individual resistances;

$$R_{eq} = R_1 + R_2 + R_3 + \cdots \ldots$$

For identical resistance in series : $R_{eq} = nR$ (n: number of resistance)

Q1: In the figure shown three resistors are connected to a potential difference 12 V.

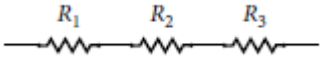


1- What is the equivalent resistance of the three resistors?

2- Calculate the current for each resistor.

A- 50 Ω , 0.2A B- 30 Ω , 0.2A C- 30 Ω , 0.4A D- 50 Ω , 0.4A

Q2: Three identical resistors, R_1, R_2, and R_3, are wired together as shown in the figure. An electric current is flowing through the three resistors. The current through R_2



A) is the same as the current through R_1 and R_3.

B) is a third of the current through R_1 and R_3.

C) is twice the sum of the current through R_1 and R_3.

D) is three times the current through R_1 and R_3.

Q3: Which of the following is an incorrect statement?

a) The currents through electronic devices connected in series are equal.

b) The potential drops across electronic devices connected in parallel are equal.

c) More current flows across the smaller resistance when two resistors are in parallel connection.

d) More current flows across the smaller resistance when two resistors are in serial connection

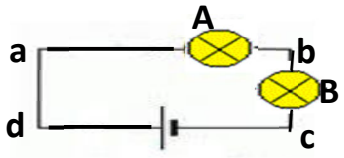
The brightness of lamps in series connection:

From the equation $P=I^2R$, the lamp with higher resistance has a higher brightness .

Q4: A learner connected two lamps A and B as in the figure with a battery, and noticed that the brightness of lamp A is greater than the brightness of lamp B. Answer the following

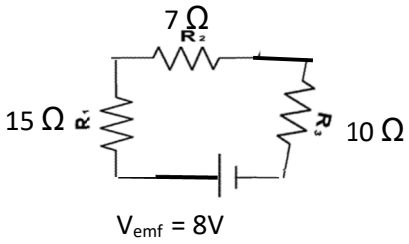
1 -What does the difference in brightness of the two lamps indicate. $R_A > R_B$

2 -If the learner connects point b to point a with a connecting wire without resistance, what will happen to the brightness of each of the two lamps?



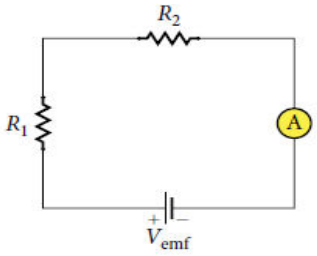
Q5: Depending to figure V3 equal to :

A-1.5V B- 2.5V C- 3.5V D- 4.



Q6: Two resistors, R_1 = 3.00 Ωand R_2 = 5.00Ω , are connected in series with a battery with V_{emf} = 8.00 V and an ammeter, as shown in the figure. What is the current measured by the ammeter

A-0.5A B- 0.88A C- 1.5A Dd- 1A



Q7: Three resistors, 3.0 Ω, 5.0 Ω, and 4.0 Ω, are connected in series across a 9.0 V battery. What is the current in the circuit?

A. 0.75 A B. 3.0 A C. 1.8 A D. 2.3 A

Q8: Four resistors, 1.0 Ω, 3.0 Ω, 5.0 Ω, and 4.0 Ω, are connected in series with a 9.0 V battery.

What is the equivalent resistance of the circuit?

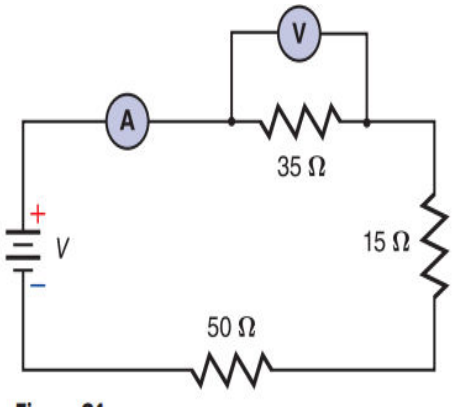
A. 0.6 Ω B. 6.0 Ω C. 1.8 Ω D. 13 Ω

Q9: Eiman connects eight 12 Ω lamps in series. What is the total resistance of the circuit?

A. 0.67 Ω B. 12 Ω C. 1.5 Ω D. 96 Ω

Q10: From the Figure shown, the voltmeter reads 70.0 V.

a. Which resistor is the hottest?

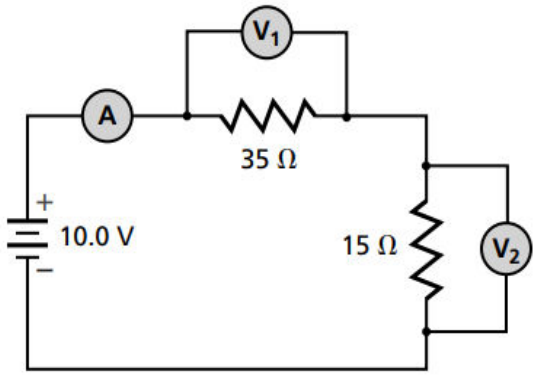


b. Which resistor is the coolest?

c. What will the ammeter read?

d. What is the power supplied by the battery?

Q11: Refer to Figure to answer the following questions.



a. What should the ammeter read?

b. What should voltmeter 1 read?

c. What should voltmeter 2 read?

Q12: A 9-V battery is in a circuit with three resistors connected in series.

a. If the resistance of one of the resistors increases, how will the equivalent resistance change?

.

b. What will happen to the current?

Voltage dividers:

Suppose you have a 9 V battery, but you need a potential difference of 5 V for an electric circuit.

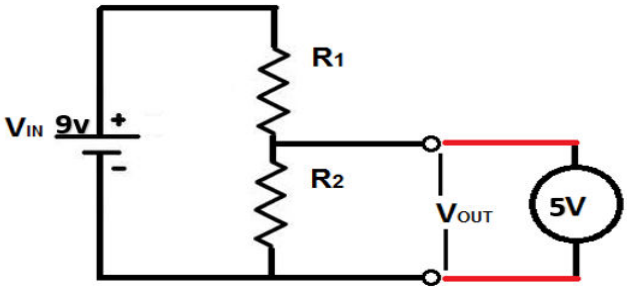
How can you produce a potential difference of 5 V if your battery produces a potential difference of 9 V?

You could use a type of series circuit called a voltage divider. A voltage divider produces a source of potential difference that is less than the potential difference across the battery.

$$\Delta V2 = IR_2$$

$$\Delta V2 = (\frac{\Delta V}{R_1 + R_2})R_2$$

$$\Delta V1 = (\frac{\Delta V}{R_1 + R_2})R_1$$

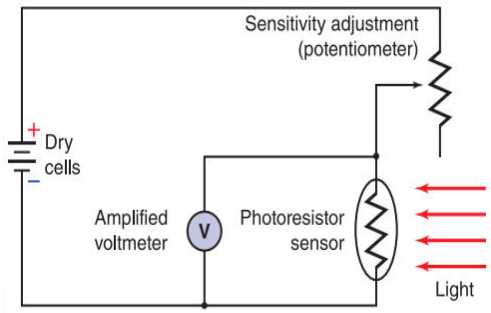


Photoresistors:

Voltage dividers often are used with sensors, such as photoresistors.

A photoresistor's resistance depends on the amount of light that strikes it.

The photoresistor resistance decrease when light is striking it , and increase in dark .



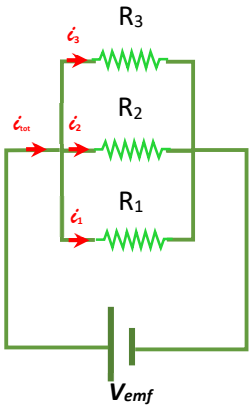
The voltage output of a voltage divider that uses a photoresistor

- depends upon the amount of light striking that photoresistor at the time. And convert it to a measurement of illuminance That can be read on the digital display. Light meters used in photography.

Q13: A student makes a voltage divider from a 45-V battery, a 475-kΩ resistor, and a 235-kΩ resistor. The output is measured across the smaller resistor. What is the voltage?

Q14: Select a resistor to be used as part of a voltage divider along with a 1.2-kΩresistor. The drop across the 1.2-kΩ resistor is to be 2.2 V when the supply is 12 V.

Resistors in Parallel:



-All resistors in parallel group have the same electric potential (voltage);

$$V_1 = V_2 = V_3 = \ldots\ldots = V_{tot}$$

-The electric current in each resistor is inversely proportional to its resistance; $i \propto \frac{1}{R}$

-The total current equals the sum of the individual currents;

$$i_{tot(parallel\ group)} = i_1 + i_2 + i_3 + \ldots\ldots\ldots$$

-The reciprocal of the equivalent resistance equals the sum of reciprocals of the individual resistances;

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$$

$$R_{eq} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots\right)^{-1}$$

For identical resistance:

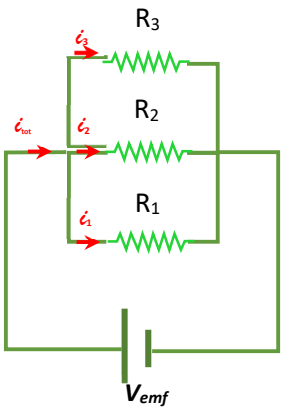
$R_{eq} = R / n$ (n: number of resistance)

Q15: Three resistors R1 = 1.00 Ω, R2 = 2.00 Ω, and R3 = 2.00 Ω, are connected in parallel. The parallel connection is attached to a 3.00 V voltage source.

(a) What is the equivalent resistance?

(b) Find the current supplied by the source to the parallel circuit.

(c) Calculate the currents in each resistor and show that these add together to equal the current output of the source.



Solution:

(a) $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R} + \frac{1}{R_3} \Rightarrow \frac{1}{R_{eq}} = \frac{1}{1} + \frac{1}{2} + \frac{1}{2} \Rightarrow R_{eq} = 0.5\ \Omega$

(b) $i_{tot} = \frac{V_{tot}}{R_{eq}} \Rightarrow i_{tot} = \frac{3}{0.5} \Rightarrow i_{tot} = 6\ A$

(c) $i_1 = \frac{V_1}{R_1} \Rightarrow i_1 = \frac{3}{1} \Rightarrow i_1 = 3\ A$

$i_2 = \frac{V_2}{R_2} \Rightarrow i_2 = \frac{3}{2} \Rightarrow i_1 = 1.5\ A$

$i_3 = \frac{V_3}{R_3} \Rightarrow i_3 = \frac{3}{2} \Rightarrow i_3 = 1.5\ A$

$i_1 + i_2 + i_3 = 3 + 1.5 + 1.5 = 6\ A = i_{tot}$

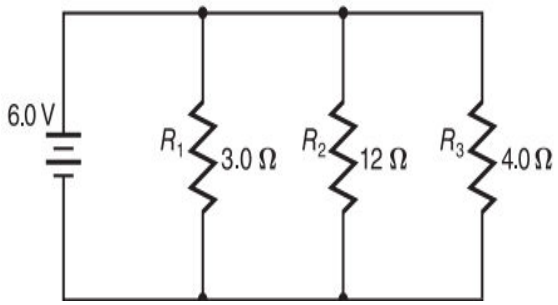
Note:

1- If one of the lamps burns out or is removed from its place, the brightness of the rest of the lamps will not be affected.

2- When adding a new lamp in parallel, the brightness of any lamp is not affected, and the value of the current passing through each lamp is not affected. However, the total current passing through the circuit increases because the equivalent resistance decreases:

Q16: Which is the equivalent resistance of the circuit shown below?

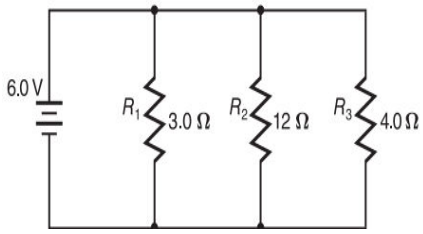
A. 3 Ω B. 1.5 Ω C. 1.0 Ω D. 19 Ω



Q17: Three resistors, 3.0 Ω, 12 Ω, and 4.0 Ω, are connected in parallel across a 6.0 V battery.

What is the current through the battery?

A. 0.32 A B. 1.2 A C. 0.80 A D. 4.0 A



Q18: Three 15.0Ω resistors are connected in parallel and placed across a 30.0-V battery.

a. What is the equivalent resistance of the parallel circuit?

b. What is the current through the entire circuit?

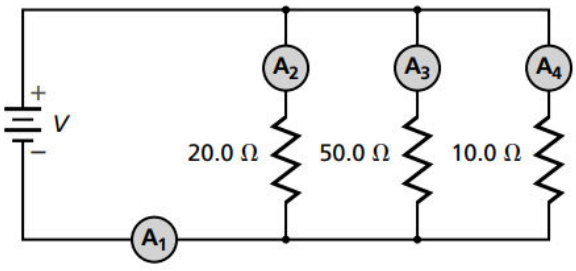
c. What is the current through each branch of the circuit?

<u>The brightness of lamps in Parallel connection :</u>

From the equation **$P = V^2 / R$** , the lamp with Lower resistance has a higher brightness .

Q19: From the Figure shown, the battery develops 110 V.

a. Which resistor is the hottest?



b. What will ammeter 1 read?

Q20: You make a parallel combination of resistors consisting of resistor A having a very large resistance and resistor B having a very small resistance. The equivalent resistance for this combination will be:

□ slightly greater than the resistance of the resistor A.
□ slightly less than the resistance of the resistor A.
□ slightly greater than the resistance of the resistor B.
□ slightly less than the resistance of the resistor B.

Kirchhoff's Rules:

1- The loop rule : The loop rule is based on the law of conservation of energy.

(The sum of increases in electric potential around a loop in an electric circuit equals the sum of decreases in electric potential around that loop).

Example :

Electric potential increases by 9 V as this charge travels through the battery,

and electric potential drops by 5 V as this charge travels through resistor 1.

What will be the change in potential as the charge travels through resistor 2?

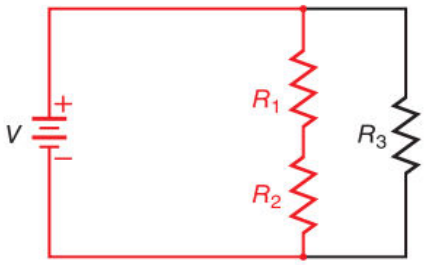
Ans:

Because the increases in electric potential around a loop

must equal the decreases in electric potential around that loop,

the drop in electric potential across resistor 2 must be

9 V – 5 V = 4 V

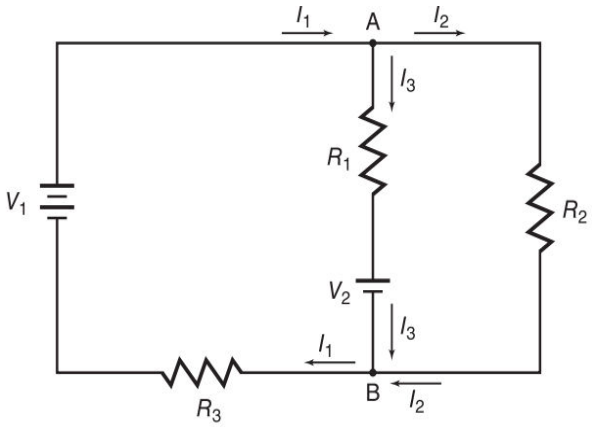


2- The junction rule: The junction rule describes currents and is based on the law of conservation of charge.

(In an electric circuit, the total current into a section of that circuit must equal the total current out of that same section.)

A junction is a location where three or more wires are connected together.

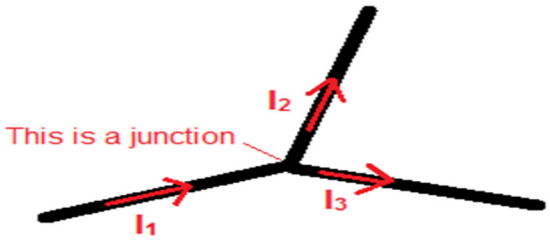
(The sum of currents entering a junction is equal to the sum of currents leaving that junction).



$I_1 = I_2 + I_3$ at junction A, and $I_2 + I_3 = I_1$ at junction B.

Q21: Depending to figure

If I_1 = 10A and I_2 = 6A .

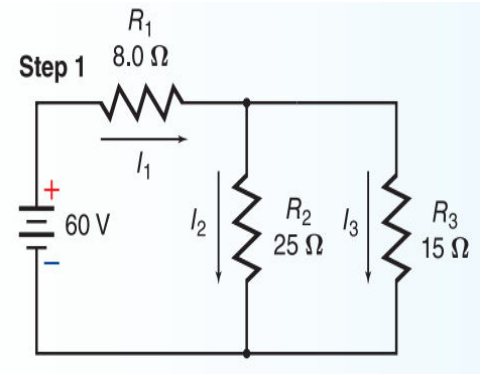


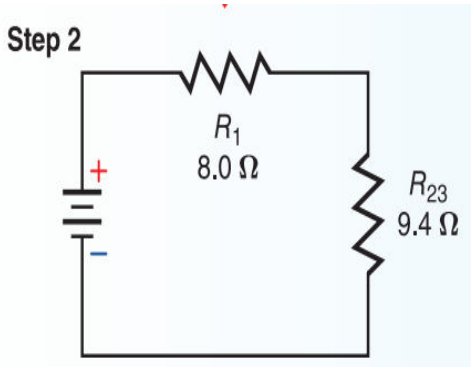
Find I_3?

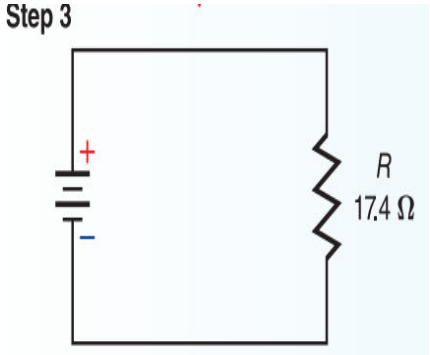
Ans:

$I_1 = I_2 + I_3$ 10 = 6 + I3 I_3 = 10 - 6 = 4A

Combined Series-Parallel Circuits:



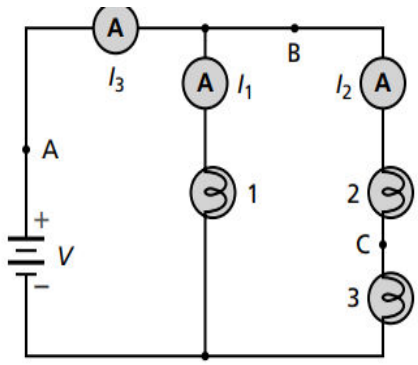




Q22: Refer to Figure. The bulbs in the circuit are identical.

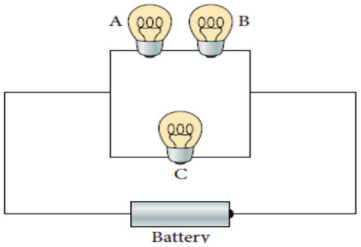
a- How do the bulb brightnesses compare?

b- If I_3 measures 1.7 A and I_1 measures 1.1 A, how much current is flowing in bulb 2?



Q23: All three light bulbs in the circuit shown in the figure are identical. Which of the three shines the brightest?

□ A □ B □ C □ A and B



Q24: All of the six light bulbs in the circuit shown in the figure are identical. Which ordering correctly expresses the relative brightness of the bulbs?

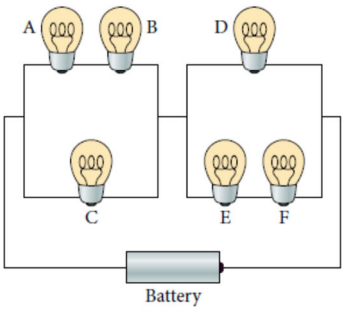
(Hint: The more current flows through a light bulb, the brighter it is!)

□ A = B > C = D > E = F

□ A = B = E = F > C = D

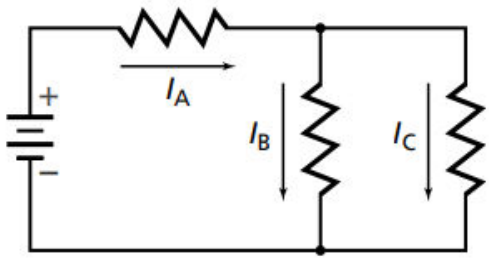
□ C = D > A = B = E = F

□ A = B = C = D = E = F



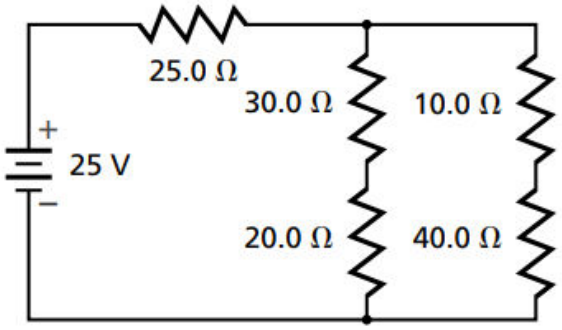
Q25: Refer to Figure and assume that all the resistors are 30.0 Ω.

Find the equivalent resistance?



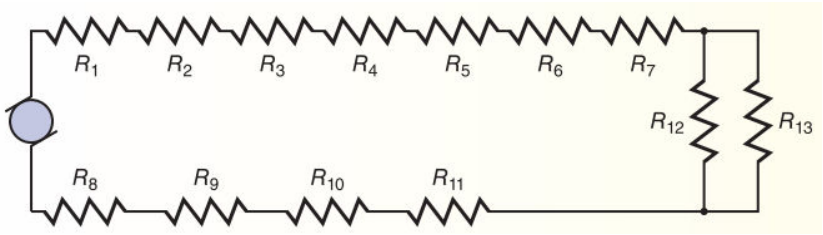
Q26: Refer to Figure and calculate:

1- the total resistance



2- the current through the 25-Ω resistor

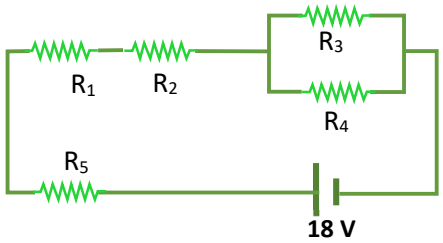
Q27: If the 13 lights shown in the figure are identical, which of them will burn brightest?



Q28: Five resistors R1 = 1.00 Ω, R2 = 2.00 Ω, R3 = 3.00 Ω, R4 = 6.00 Ω, and R5 = 4.00 Ω, are connected as shown in figure. 18.00 V battery is attached to group.

(a) What is the equivalent resistance?

(b) Find the current supplied by the source to the circuit.



Solution:

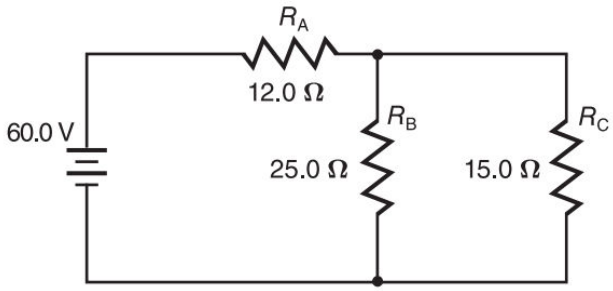
(a) $R_{34} = (\frac{1}{R_3} + \frac{1}{R_4})^{-1} \Rightarrow R_{34} = \left(\frac{1}{3} + \frac{1}{6}\right)^{-1} \Rightarrow R_{34} = 2\ \Omega$

$R_{eq} = R_1 + R_2 + R_{34} + R_5 \Rightarrow R_{eq} = 1 + 2 + 2 + 4 \Rightarrow R_{34} = 9\ \Omega$

(b): $i_{tot} = \frac{V_{tot}}{R_{eq}} \Rightarrow i_{tot} = \frac{18}{9} \Rightarrow i_{tot} = 2\ A$

Q29: Which is the current through the battery in the circuit shown below?

A. 1.15 A B. 2.80 A C. 2.35 A D. 5.61 A



Q30: What is the current in the circuit shown in the figure when the switch is

(a) open?

(b) closed?

