Electricity:

1) Read and take notes:

2) **PhET simulations**: **John Travoltage**:
   is an example of
   1) charging by friction and
   2) charging by contact.

   Explain how?

3) **PhET simulations: Balloons and Static Electricity:**
   is an example of
   1) charging by friction;
   2) how unlike charges attract each other
   3) how like charges repel each other.

   Explain how?

Electric Field

1) Read and take notes (pages 1-7)

2) **PhET simulation: Charges and Fields:** Notes the direction of the electric field;

Coulomb's Law;

$$F = k\frac{|q_1||q_2|}{r^2}$$

F : electrostatic force in Newton (N).
q_1, q_2 : is the charge in coulomb (C).
r : is the distance in meter (m).
K: is a constant = 8.99×10^9 $N.m^2/C^2$

1) Read and take notes (pages 1-6)

2) **PhET simulation: Coulomb's Law**

Explain how the electrostatic force (F) is:

(a) attractive if the charges have unlike signs (-, +).
(b) repulsive if the charges have like signs (-,-) or (+,+).

3) **a) MATH: Look at the equation of F,**

PREDICT and answer:

1) What happens to the electrostatic force (F) when q_1 or q_2 increases? Increases or decreases
2) What happens to the electrostatic force (F) when q_1 or q_2 decreases? increases or decreases

b) SIMULATION:

Change the values for q_1 or q_2 and notice the changes of the electrostatic force (F).

4) **a) MATH: Look at the equation of F,**

PREDICT and answer:

1) What happens to the electrostatic force (F) when r increases? Increases or decreases
2) What happens to the electrostatic force (F) when r decreases? increases or decreases

b) SIMULATION:

Change the values for r and notice the changes of the electrostatic force (F).

Electric Potential, Current and Resistance

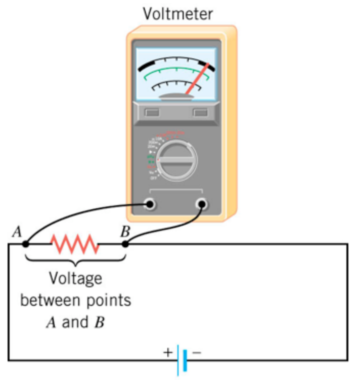
Electric Potential:

The potential difference (ΔV) between two points A and B in an electric field is the work done per unit charge as a charge is moved between these points:

$$\Delta V = V_B - V_A$$

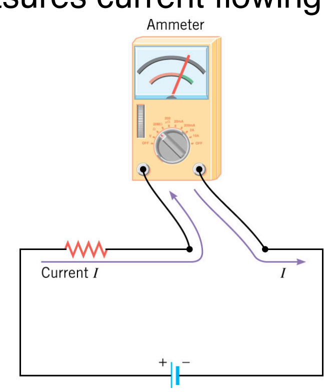
SI Unit of Electric Potential: joule/coulomb = volt (V)

Voltmeter: measures voltage across some device in the circuit

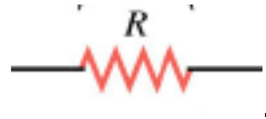


Electric Current (I):

When electrons move through a conductor, they constitute an electric current. Within a battery, a chemical reaction occurs that transfers electrons from one terminal to another terminal. By definition, the direction of the current *I* in a circuit is the direction in which the positive charges would move.
SI unit for electric current is: One coulomb per second equals one ampere (A). If the charges move around the circuit in the same direction at all times, the current is said to be direct current (dc) --> e.g. simple circuits with batteries are normally dc. **Ammeter-** measures current flowing in the circuit

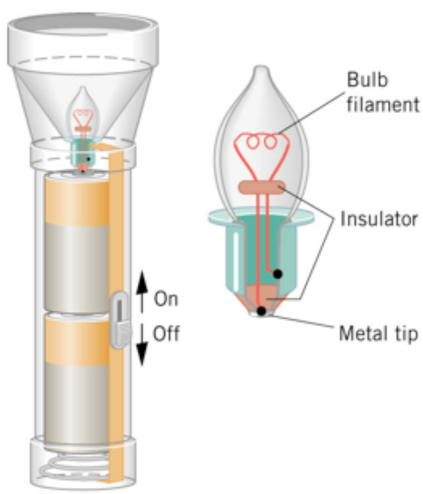
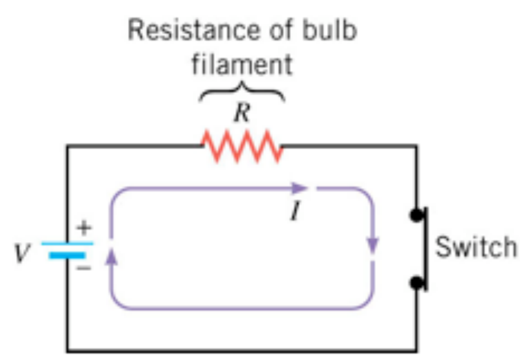


Resistance in Electric Circuits (R)

When electrons pass through a device that uses their electrical energy, they experience an opposition or resistance (R), to their flow
To the extent that a wire or an electrical device offers resistance to electrical flow, it is called a **resistor.** The symbol of a resistor is  .

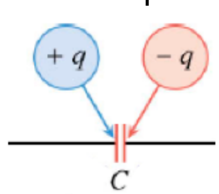
Electric Circuit

In an electric circuit, an energy source and an energy consuming device are connected by conducting wires through which electric charges move.

Flashlight	Circuit Schematic Electric Circuit Drawing of the Flashlight
	

Storing Charges: The Capacitor

Capacitor is used to store electric charge. SI Unit of Capacitance: coulomb/volt = farad (F). The symbol for capacitor in an electric circuit is



Ohm’s Law

George Simon Ohm (1787-1854), a German physicist: The resistance (*R*) is defined as the ratio of the voltage *V* applied across a piece of material to the current I through the material.

$$\frac{V}{I} = \underbrace{R}_{\text{Resistance}} = \text{constant} \qquad \text{or} \qquad V = IR$$

SI Unit of Resistance: volt/ampere (V/A) = ohm (**Ω**)

Power (P) in Electric Circuits

The rate at which a load uses energy is defined as Power (P) . When there is current (I) in a circuit as a result of a voltage (V), the electric power (P) delivered to the circuit is:

$$\boldsymbol{P = IV}$$

SI Unit of Power: watt (W)

Electric Energy (E)

When electrons move through a circuit, they disperse the energy they receive from the source to the various loads they encounter. The amount to energy lost during a period of time t, is given by:

$$\mathbf{E = Pt}$$

SI Unit of Energy is Joules (J)

Ohm's Law: V = IR

PhET simulation: Ohm's Law

<u>Relationship between I and V</u>

1) Change the value of V. Notice how the value of I changes. Are V and I directly proportional or inversely proportional?
2) Take one value for R and one value for I. Calculate V = I x R. Compare the calculated value to the value given by the simulation. Repeat one more time.

<u>Relationship between I and R</u>

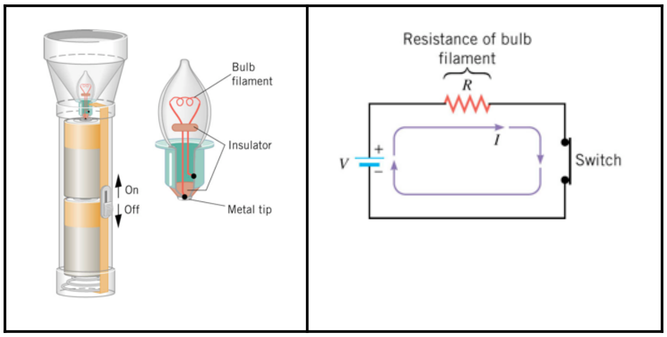
3) Change the value for R. Notice how the value for I changes. Are I and R directly proportional or inversely proportional?
4) Take one value for R and one value for V. Calculate I. Compare the calculated value to that given by the simulation.
5) Take one value for V and one value for I. Calculate R. Compare the calculated value to that given by the simulation.
6) Solve the following problem:

The flashlight uses two 1.5-V batteries to provide a current (I) of 0.40 A in the filament.

a) Find the resistance (R) of the glowing filament. (answer: 7.5 ohms)

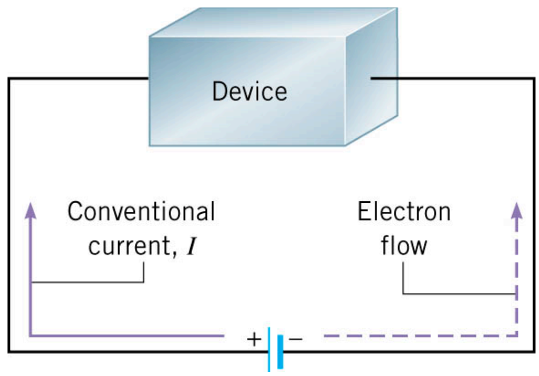
b) Find the power (P) delivered to the bulb (answer; 1.2 watts)

c) Find the energy (E) dissipated in the bulb in 5.5 minutes (or 5.5 x 60 = 330 seconds) of operation of the flashlight. (answer: 400 Joules)



"Electron Flow" current is what constitutes an electric current in a solid conductor (such as wire). It is the flow of negatively charged electrons from the negative terminal to the positive terminal of the source of electric potential.

"Conventional" current is the hypothetical flow of positive charges that would have the same effect in the circuit as the movement of negative charges that actually does occur.



Strategy in Applying Kirchhoff's Rules:

1- Draw the current in each branch of the circuit. Choose any direction.

2- Mark each resistor with a + at one end and a - at the other end in a way that is consistent with your choice for the current direction in step 1. For batteries, the signs will be the usual + for higher potential and – for lower potential.

3- Apply the junction rule and the loop rule to the circuit and obtain independent equations.

4- Solve these equations simultaneously for the unknown variables.

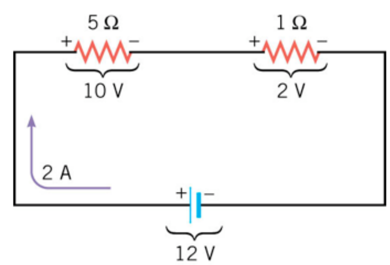
Kirchhoff's Laws of Electric Circuits

Gustav Robert Kirchhoff is a German Physicist (1824 - 1887). He described the conservation of energy and conservation of charges:

a) Kirchhoff's Voltage Law (KVL) and
b) Kirchhoff's Current Law (KCL).

KVL (Loop Rule): Around any complete path through an electric circuit (closed circuit loop), the sum of the increases in electric potential is equal to the sum of the decreases in electric potential.

$$V = V_1 + V_2 + V_3 + etc$$

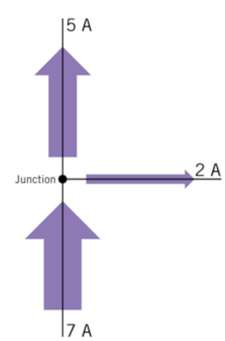


Potential rises = Potential drops

12 V = 10 V + 2 V

KCL (Junction Rule:) At any junction point in an electric circuit (I), the total electric current into the junction is equal to the total electric current out of the junction.

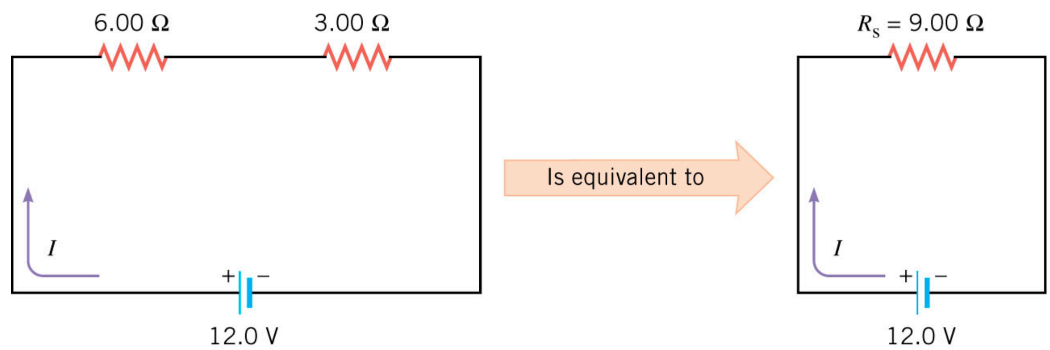
$$I = I_1 + I_2 + I_3 + etc$$



sum of into currents = sum of currents out
7 A = 2 A + 5 A

Series Circuits (Same Current I)

The electrons have only one path to follow through the circuit. The current is exactly the same current at any point is a series circuit. For batteries, the signs will be the usual + for higher potential and – for lower potential.



We can apply the following:

1) Ohm's Law: $\mathbf{V = \mathit{I}\,\mathit{R}}$

2) Kirchhoff's Loop rule (**KVL or Voltage Law**):

Potential rises = Potential drops

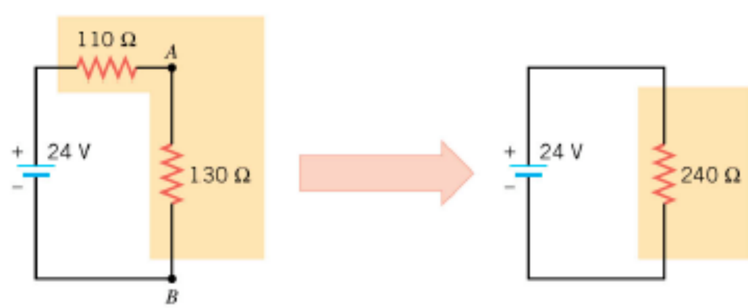
$$\mathbf{V = V_1 + V_2}$$

3) $\mathbf{R_s}$ is the equivalent resistance of the series circuit

$$\boldsymbol{R_s = R_1 + R_2 + R_3 + R_4 + R_5 + R_6 + \ldots}$$

4) The figure shows a circuit composed of a 24-V battery and two resistors, whose resistances are 110 and 130 Ω, and its equivalent circuit with one resistor of 240 Ω **.**

(a) Explain how the 240 Ω was calculated.
(b) Find the total current supplied by the battery (Ans: 0.1 A)
(c) Find the voltage between points A and B in the circuit. (Ans: 13 V)



(c)

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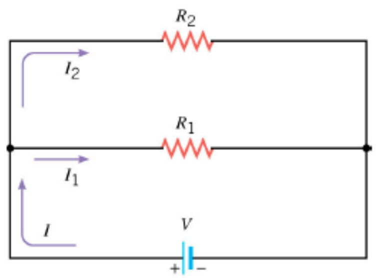
Parallel Circuits (Same Voltage V)

In a parallel circuit, the electrons (current) have a choice of several paths through the circuit, Parallel wiring means that the devices are connected in such a way that the same voltage is applied across each device.



(b)

Since R_1 and R_2 are connected in parallel, they have the same voltage (V) across them. We can apply the following:

1) Ohm's Law: $\mathbf{V = \mathit{I}\,\mathit{R}}$

2) Kirchhoff's Junction Rule (**KCL or Current law**):

$$I = I_1 + I_2$$

3) R$_s$ is the equivalent resistance of the series circuit

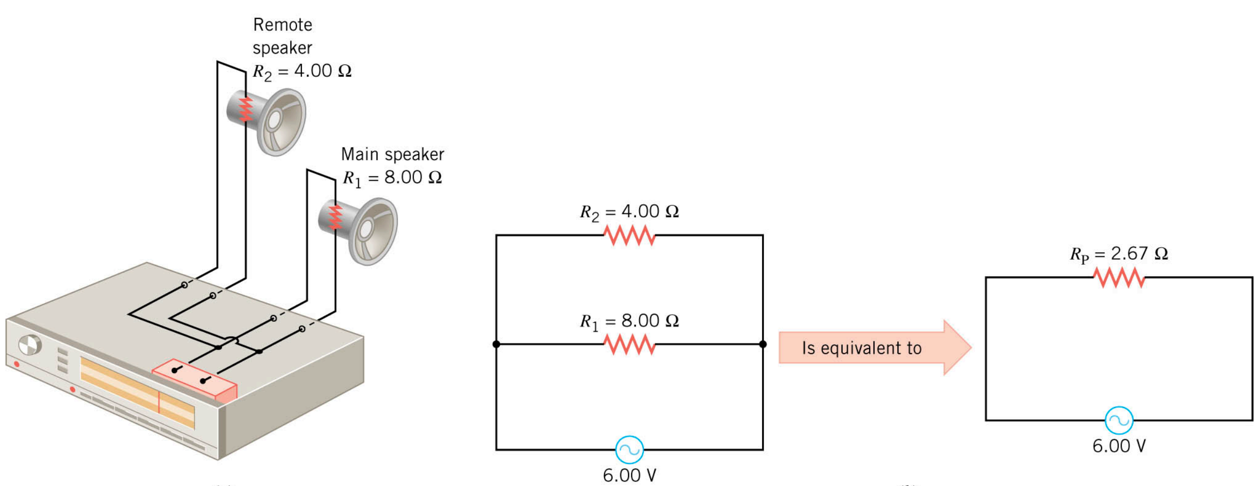
$$1/R_s = 1/R_1 + 1/R_2 + 1/R_3 + 1/R_4 + 1/R_5 + 1/R_6 + \ldots$$

4) *Main and Remote Stereo Speakers.*

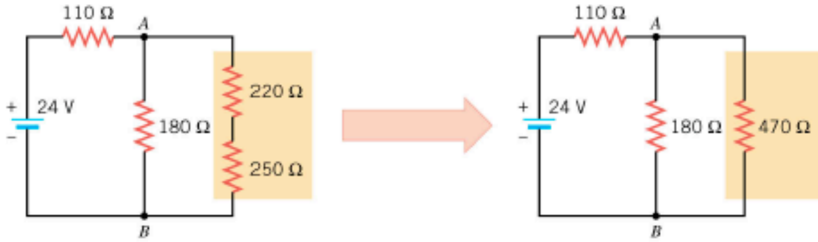
(a) Explain how the 2.67 Ω was calculated.

(b) Find the total current supplied by the receiver. (Ans: 2.25 A)

(c) Find the current in each speaker (Ans: 0.50 A, 1.50 A)



(a) (b)

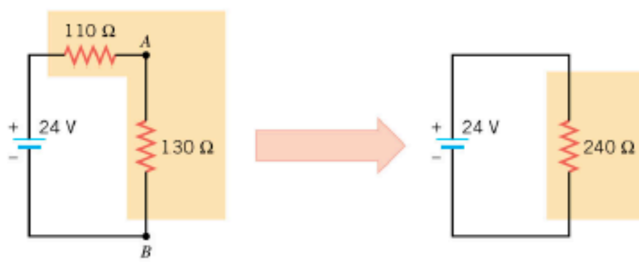


(a)

Series:
$R = 220\ \Omega + 250\ \Omega$
$= 470\ \Omega$

(b)

Parallel:
$1/R = 1/(180\ \Omega) + 1/(470\ \Omega)$
$R = 130\ \Omega$



(c)

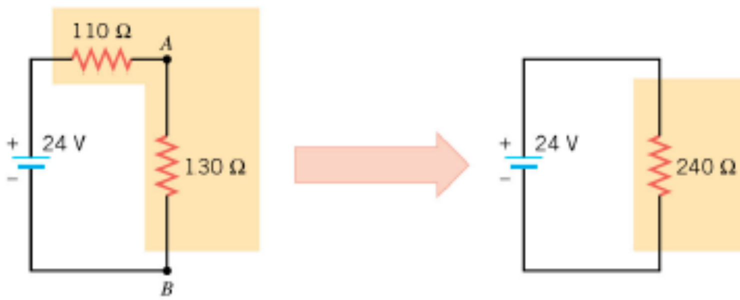
Series:
$R = 110\ \Omega + 130\ \Omega$
$= 240\ \Omega$

PhET simulation:
Circuit Construction Kit: DC- Virtual Lab

Use the simulation and construct both circuits in 1) and 2).

1) The figure shows a circuit composed of a 24-V battery and two resistors, whose resistances are 110 and 130 Ω, and its equivalent circuit with one resistor of 240 Ω .

(a) Explain how the 240 Ω was calculated.
(b) Find the total current supplied by the battery (Ans: 0.1 A)
(c) Find the voltage between points A and B in the circuit. (Ans: 13 V)



(c)

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2) ***Main and Remote Stereo Speakers.***

(a) Explain how the 2.67 Ω was calculated.
(b) Find the total current supplied by the receiver. (Ans: 2.25 A)
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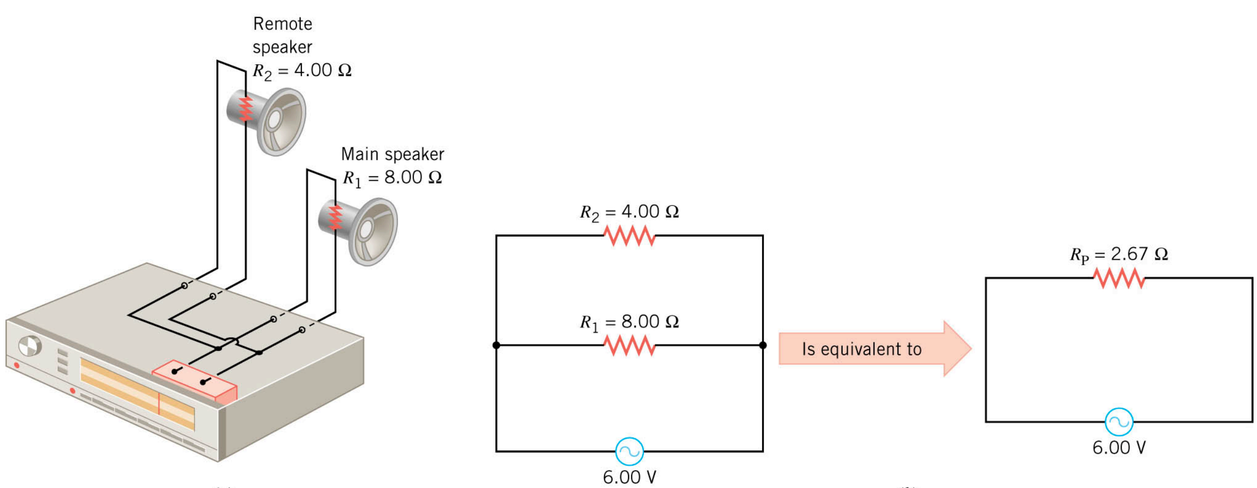
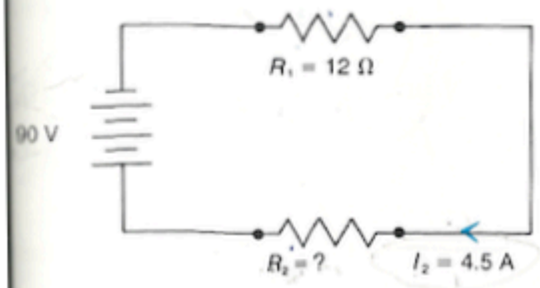


(a) (b)

(1) cuit, find V_1, V_2, I_0, I_1, and R_2.

$V_o = 90$ V



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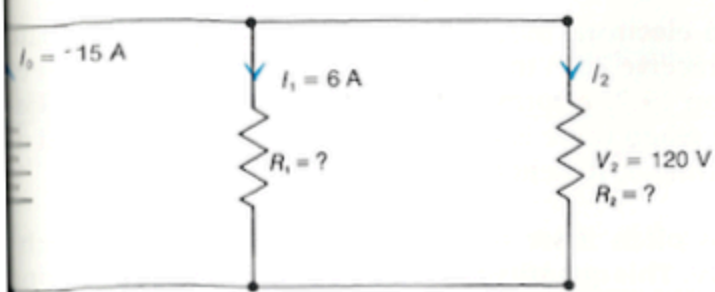
1. 54 V, 36 V, 4.5 A, 4.5 A, 8.0 Ω
2. 120 V, 120 V, 9 A, 20 Ω, 13.3 Ω
3. 15 V, 60 V, 1.5 A, 1.5 A, 1.5 A, 40 Ω
4. 180 V, 180 V, 180 V, 180 V, 3 A, 3 A, 12 A

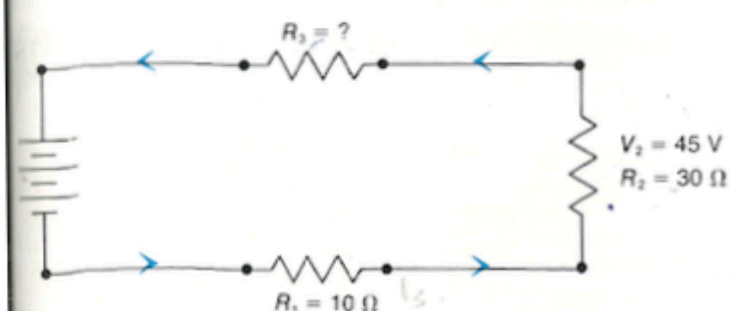
(2) cuit, find V_0, V_1, I_2, R_1, and R_2.

$V_o = ?$



(3) cuit, find V_1, V_3, I_1, I_2, I_3, and R_3.

$V_o = 120$ V



(4) rcuit, find V_0, V_1, V_2, V_3, I_0, I_1, and I_2.

$V_o = ?$