CHAPTER 3: ELECTRICITY

Section *4:*

CIRCUITS

A circuit is a closed path where current flows (charges flow). A circuit has a **source** of **potential difference** (cell or battery), a **resistance** (example: bulb), and **wires** (see figure A).

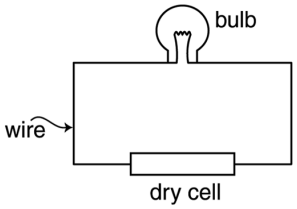


Figure A

To review: Look at figure A. The source of **potential difference** (cell or battery) pushes the charges and causes the charges to move. The wires connect the battery or cell to the resistor (example, bulb) and then back to the cell or battery, so there is a complete path for the charges to travel through. The resistor (examples: bulb, toaster, resistor) hinders the flow of charges.

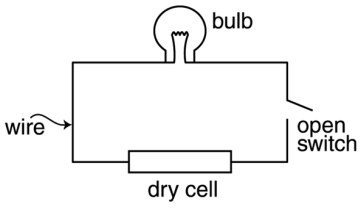


Figure B

A switch is added to the circuit (see figure B). If you open the switch, the

circuit is no longer a complete path and no current (no charge) can flow.

Table: Circuit Symbols

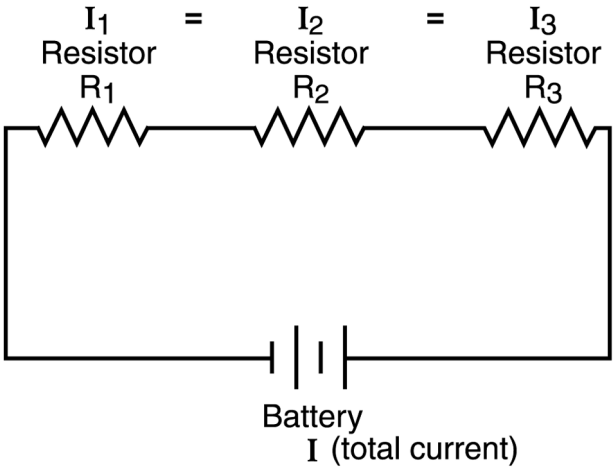
Circuit symbols are given below or on Reference Table: Circuit Symbols on page reference tables 16.

Circuit Symbols			
	cell		ammeter
	battery		resistor
	switch		variable resistor
	voltmeter		lamp

As you can see in Reference Table: Circuit Symbols above,  = resistor (has resistance).

There are two types of circuits: series and parallel.

SERIES CIRCUITS



Series Circuit

A series circuit has **only 1** path for the current (electrons) to flow.

Table: Elect

You learned, and you can see on Reference Table: Electricity on page reference tables 14-15 what I, R, and V are.

$$R = \frac{V}{I}$$

I = current

R = resistance

V = potential difference

Look at the diagram of the series circuit on the previous page. The current flows from the battery to R_1 (example: bulb) to R_2 (example: resistor or toaster) to R_3 (example: bell) and then back to the battery.

Look below or at Reference Table: Electricity Series Circuits on page reference tables 14-15.

Series Circuits

$I = I_1 = I_2 = I_3 = ...$

$V = V_1 + V_2 + V_3 + ...$

$R = R_1 + R_2 + R_3 + ...$

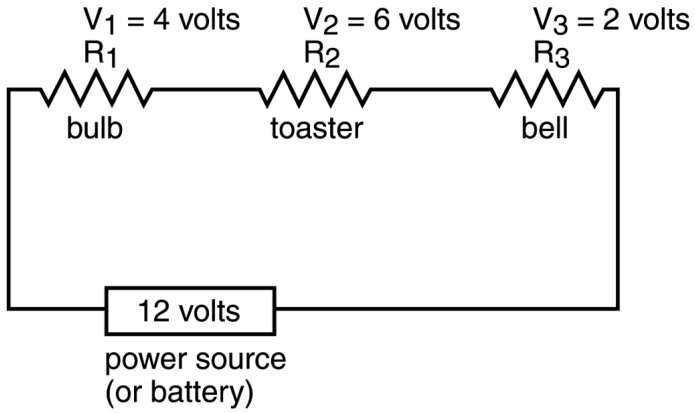
In a **series circuit**, the **current** (I) is the same in all parts of the circuit (see diagram of series circuit on the previous page).

I_1, (which means the current at R_1) = **I_2**, (current at R_2) = **I_3**, (current at R_3). Current at any point in the circuit is the same as the current (I) coming out of the battery.

I	$=$	I_1	$=$	I_2	$=$	I_3
current from battery or cell or power source						

In a series circuit (see diagram below),

V	$=$	V_1	$+$	V_2	$+$	V_3
Potential difference from power source or cell or battery		Potential difference across R_1		Potential difference across R_2		Potential difference across R_3



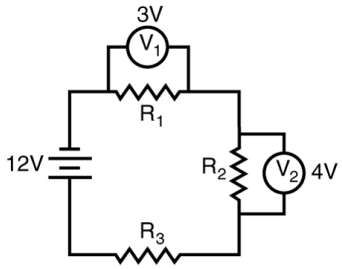
Look at the diagram on the previous page:

V	=	V_1	+	V_2	+	V_3
12 volts from the power source or battery	=	4 volts across R_1	+	6 volts across R_2	+	2 volts across R_3

The total number of volts from the power source (battery or cell) (example: 12 volts)= sum of the voltages (sum of all the volts) across all the resistances (example: 4 volts + 6 volts + 2 volts).

A voltmeter is an instrument that measures potential difference (volts).

Question: The diagram below shows three resistors, R_1, R_2, and R_3, connected to a 12-volt battery.



If voltmeter V_1 reads 3 volts and voltmeter V_2 reads 4 volts, what is the potential drop (potential difference) across resistor R_3?

(1) 12 V (2) 5 V (3) 0 V (4) 4 V

Solution:

Given: V_1 is 3 V (volts), V_2 is 4 V (volts), battery is 12 V (volts).
Find: Potential drop across resistor R_3, which means find V_3.
Look at the figure in the question. You know it is a **series circuit** because there is only **one path** for the current (charges) to flow.

On Reference Table: Circuit Symbols,  = voltmeter, given on page reference tables 16. In the figure in the question, a voltmeter and another voltmeter are added to the circuit to measure potential difference (volts). The voltmeters are added on to the circuit; they do not affect whether the circuit is series or parallel.

Look for an equation on Reference Table: Electricity series circuits having to do with V_1, V_2, V_3 and total volts (V) from the battery or power source.

Use the equation

$V = V_1 + V_2 + V_3 + ...$

Then substitute for V_1 3 V. *Substitute for V_2* 4 V. *Substitute for V* (which is total volts from the battery) 12 V.

$12\ V = 3\ V + 4\ V + V_3$

$12\ V - 7\ V = V_3$

$V_3 = 5$ V

Potential drop (potential difference) across resistor R_3 is 5 V.

Answer *2*

Similarly, in a series circuit,

R_{eq}	=	R_1	+	R_2	+	R_3
Equivalent resistance (total resistance)		Resistance of R_1		Resistance of R_2		Resistance of R_3

R_{eq} = equivalent resistance, given on Reference Table: Electricity.

In the equation above, R means resistance (examples: resistance of bulb, toaster, resistor ⁄\⁄\⁄, bell, etc). Resistance hinders (slows down) the flow of current (charge).

Question: R_1 (bulb) = 100 Ω; R_2 (toaster) = 12 Ω; and R_3 (bell) =4 Ω in the series circuit diagram on page 3:59. Find the total (equivalent) resistance.

Solution:

Given: Series circuit; R_1 = 100 Ω; R_2 = 12 Ω; R_3 = 4 Ω.

Find: R_{eq} Equivalent resistance (total resistance).

Look for an equation on Reference Table: Electricity series circuits for equivalent resistance (R_{eq}).

Use the equation

R_{eq}	=	R_1	+	R_2	+	R_3
Equivalent resistance (total resistance)		Resistance of R_1		Resistance of R_2		Resistance of R_3

In the equation above, *substitute for* R_1 100 Ω. *Substitute for* R_2 12 Ω. *Substitute for* R_3 4 Ω.

$R_{eq} = R_1 + R_2 + R_3$

$\mathbf{R_{eq}} = 100\ \Omega + 12\ \Omega + 4\ \Omega = \mathbf{116\ \Omega}$.

Equivalent resistance (total resistance)

Total resistance (equivalent resistance R_{eq}) = 116 Ω

In a series circuit, total resistance (equivalent resistance, R_{eq}) = sum of all the resistances.

As you can see from Reference Table: Electricity series circuits

Series Circuits

$I = I_1 = I_2 = I_3$...

$V = V_1 + V_2 + V_3$ +...

$R_{eq} = R_1 + R_2 + R_3$ +...

Table: Elect Series Circuit

Table: Elect Series

Tbl: Elect Series Circuits

Series Circuits: The current (I) is the same in all parts of the circuit. The total volts (from the power source, cell, or battery) = the sum of all the voltages (volts)in the circuit. The total resistance (R_{eq}) equals the sum of all the resistances in the circuit.

Table: Circuit Symbols

An ammeter -(A)- is an instrument that measures current. A voltmeter -(V)- is an instrument that measures voltage(volts) (potential difference). Symbols for ammeter -(A)-, voltmeter -(V)-, cell ⊣, and battery ⊣⊣⊣ are given on Reference Table: Circuit Symbols on page reference tables 16.

Now Do Homework Questions # 91-94, pages 138-139.

Question: The diagram shows a circuit with two resistors.
What is the reading on ammeter A?
(1) 1.3 A (2) 1.5 A
(3) 3.0 A (4) 0.75 A

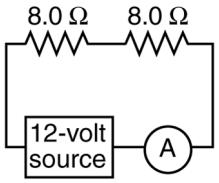
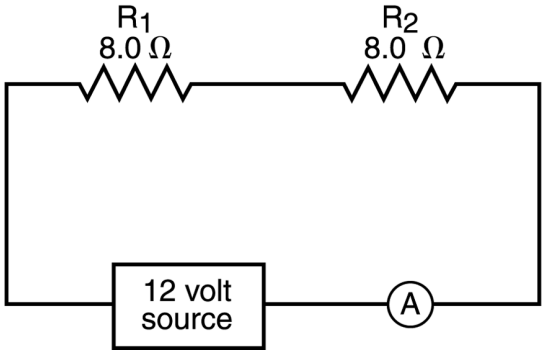


Table: Circuit Symbols

Solution:
Given: ⩘ = 8.0 Ω, ⩘ = 8.0 Ω.
Diagram has 12 volt source (total volts = 12 volts).
Find: reading on ammeter A. An ammeter measures current; therefore, find I (current).

⩘ = resistor (has resistance), given on Reference Table: Circuit Symbols.
Look at the diagram below.



Label one resistor R_1; R_1 = 8.0 Ω. Label the other resistor R_2;R_2 = 8.0 Ω.
Look for an equation on Reference Table: Electricity that has

resistance (R), volts (potential difference *V*, which is in volts V), and current (I). *Use the equation:*

$$R = \frac{V}{I}.$$

I = current
R = resistance
V = potential difference

In the equation above, you have two unknowns, I (current) and R_{eq} (total resistance); therefore, first find the total resistance (R_{eq}) and then substitute R_{eq} and V in the equation $R = \frac{V}{I}$ to find current (I).

First find the total resistance R_{eq}. By looking at the figure in the question, you know that it is a series circuit, because there is only one path for the current to flow. Look for an equation on Reference Table: Electricity Series Circuits that has total resistance R_{eq}, R_1 and R_2. Use the equation:

$R_{eq} = R_1 + R_2 + R_3...$

Substitute for R_1 8.0 Ω. Substitute for R_2 8.0 Ω.

$R_{eq} = 8.0\ \Omega + 8.0\ \Omega = 16\ \Omega$

R_{eq} (total resistance) = 16 Ω

Then, in the equation $R = \frac{V}{I}$, *substitute for R* (total resistance) 16 Ω. *Substitute for V* (potential difference, which equals total number of volts) 12 V (volts).

$$R = \frac{V}{I}$$

$$16\ \Omega = \frac{12\ V}{I}$$

Cross multiply

$I(16\ \Omega) = 12V$

$$I = \frac{12\ V}{16\ \Omega} = 0.75\ A$$ Answer *4*

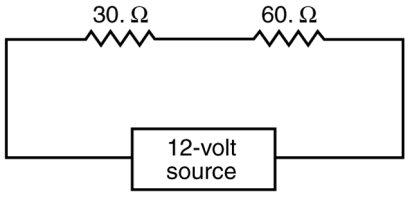
Or rearrange the equation

$$I = \frac{V}{R}$$

$$I = \frac{12\ V}{16\ \Omega} = 0.75A$$ Answer *4*

Note: In a series circuit, the current (I) is the same in all parts of the circuit and is equal to the total current (from battery or power source). $I = I_1 = I_2 = I_3 = ...$

Question: A 30. ohm resistor and a 60. ohm resistor are connected in an electric circuit as shown at right.



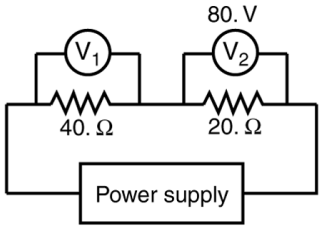
Compared to the electric current through the 30. ohm resistor, the current through the 60. ohm resistor is

(1) smaller (2) larger (3) the same

Solution: By looking at the figure in the question, you know it is a series circuit, because there is only one path for the current to flow. In a series circuit, the current is the same in all parts of the circuit. $I = I_1 = I_2 = I_3 = ...$, given on Reference Table: Electricity Series Circuits.

Therefore, I (current) through the 30. Ω resistor equals I (current) through the 60. Ω resistor. Answer *3*

Question: In the circuit shown on the next page, voltmeter V_2 reads 80. volts.



What is the reading of voltmeter V_1?

(1) 160 V (2) 80.V (3) 40. V (4) 20. V

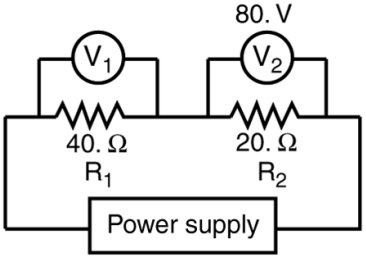
Solution: There are two methods to solve this question. Choose whichever method is easier.

Method 1:

Given: V_2 = 80. V across 20. Ω ⁄\/\/\, given in diagram above.

V_1 is across 40. Ω ⁄\/\/\, given in diagram above.

Find: reading of V_1 (voltmeter 1).



By looking at the figure in the question, you know it is a series circuit because there is only one path for the current to flow through the resistors (example R_1 and R_2).

In the circuit diagram above, ⁄\/\/\ = resistor (has resistance R).

Look for an equation on Reference Table: Electricity that has resistance (R) and volts (or potential difference) (V).

Use the equation

$R = \frac{V}{I}$.

I = current

R = resistance

V = potential difference

You need to find V_1. You know R_1 (given) but you have two unknowns, V_1 and I_1 (current at R_1).

Therefore, **first find I** (in a series circuit, I is the same in all parts of the circuit: $I = I_1 = I_2 = I_3 = ...$, given on Reference Table: Electricity Series Circuits) and then substitute I in the equation $R = \frac{V}{I}$ to **find V_1**.

First find I (current) in the **part** of the **circuit** with **V_2 (80. V)** and **R_2 (20. Ω)** (see diagram in question) because, when you use the equation $R = \frac{V}{I}$, R and V are given and there is only one unknown, I (current).

Table: Electricity

In the equation $R = \frac{V}{I}$, *substitute for R* 20. Ω. *Substitute for V* 80. V.

$R = \frac{V}{I}$

$20.\ \Omega = \frac{80.\ V}{I}$

Cross multiply

$I(20.\ \Omega) = 80.\ V$

$I = \frac{80.\ V}{20.\ \Omega} = 4.0$ A (amperes)

Or, rearrange the equation

$I = \frac{V}{R}$

$I = \frac{80.\ V}{20.\ \Omega} = 4.0$ A

You learned in a series circuit, I (current) is the same in all parts of the circuit, therefore **4.0 A** is **I (current)** in **all parts** of the **circuit**.

Table: Electricity

Then substitute for I 4.0 A in the equation $R = \frac{V}{I}$ to find V_1.

Look at the part of the diagram in the question at V_1.

Substitute for R 40. Ω(see the diagram at V_1).

$R = \frac{V}{I}$

$40.\ \Omega = \frac{V}{4.0\ A}$

Cross multiply

$V = (4.0\ A)(40.\ \Omega) = 160 A\Omega$

$= 160$ V

Answer *1*

Or, rearrange the equation

$V = IR$

$V = (4.0\ A)(40.\ \Omega) = 160\ A\Omega$

$= 160$ V

Answer *1*

Note: $R = \frac{V}{I}$

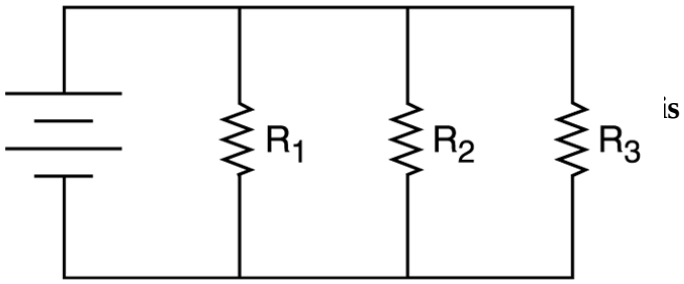
$ohms\ (\Omega) = \frac{volts\ (V)}{amperes\ (A)}$

Cross multiply: Amperes (A) x ohms(Ω) = volts (V) or A Ω= V.

Method 2:

Now Do Homework Questions #95-98, page 139.

PARALLEL CIRCUITS



is

Parallel Circuit

Note:  means battery (given on Reference Table: Circuit Symbols).

A parallel circuit has **more than one path** (2 or 3, etc.) for the current (charges) to flow.

CHAPTER 1: MECHANICS

VELOCITY

40 m/s is speed.
40 m/s south is **velocity**.
Velocity is **speed** (example 40 m/s) **and direction** (south).

You learned speed is **how fast** it moves.
Velocity is **how fast** it moves **and** in what **direction**.

3. **Average velocity** ($\bar{v}$):

a. You learned, to find average speed or average velocity, use the equation

$$\bar{v} = \frac{d}{t}$$

$$\text{average velocity or average speed} = \frac{(total)\ distance}{(total)\ time}$$

Look at the equation given below, or on Reference Table: Mechanics on pages Reference Tables 22-23 . Use equations given on the reference table to help you solve problems. (The box on the side of the page shows that the equation is given on Reference Table: Mechanics.)

$$\bar{v} = \frac{d}{t}$$

d = displacement/distance

t = time interval

$\bar{v}$ = average velocity/average speed

b. Another way to find the average velocity: add the initial velocity (the starting velocity v_i) and the final velocity (the velocity at the end v_f) and divide them by 2. The equation is:

$$\bar{v} = \frac{v_i + v_f}{2}.$$

$$\text{Average velocity} = \frac{initial\ velocity + final\ velocity}{2}$$

Memorize the equation; it is not given on the reference table.

Question: A car begins to ride at 20 m/s north and finishes at 30 m/s north. What is the average velocity?

Solution: Write down what is given and what you need to find.
Given: Beginning velocity (initial velocity)(v_i) = 20 m/s north. Velocity at the end, final velocity (v_f) = 30 m/s north.

Find: Average velocity $\bar{v}$.

Use the equation:

$$\bar{v} = \frac{v_i + v_f}{2}$$

Then substitute for v_i (initial velocity) 20 m/s north and *substitute for* v_f. (final velocity) 30 m/s north.

$$\bar{v} = \frac{20\ m/s\ north + 30\ m/s\ north}{2} = 25 \text{ m/s north}$$

Question: A car having an initial speed of 16 meters per second is uniformly brought to rest in 4.0 seconds. How far does the car travel during this 4.0 second interval?

(1) 32 meters (2) 82 meters (3) 96 meters (4) 4.0 meters

Solution: Write down what is given and what you need to find.
Given: initial speed = 16 meters per second (m/s)
final speed = brought to rest (which means final speed is zero)
time = 4 seconds
Find: How far does the car travel during this 4.0 second interval. How far means find distance (d).
Since speed (v) and time (t) are given, and the question asks you to find how far, which means distance (d), *look for an equation* below or on Reference Table: Mechanics, on pages reference tables 22-23, that has v (speed), t (time), and d (distance).

Table: Mechanics

Use the equation

$$\bar{v} = \frac{d}{t}$$

d = displacement/distance
t = time interval
$\bar{v}$ = average velocity/average speed

$\bar{v}$ is **average speed** or average velocity. The line over the v means average.

In the question, you were given initial speed (16 m/s) and final speed (at rest, which means 0 m/s) but not average speed ($\bar{v}$) . In this equation $\bar{v} = \frac{d}{t}$, you don't know both $\bar{v}$ (average speed) and d (distance), (two unknowns); therefore, *first find* $\bar{v}$ and then substitute $\bar{v}$ in the equation $\bar{v} = \frac{d}{t}$ to find d (distance).

First find $\bar{v}$ (average speed). *Use the equation* $\bar{v} = \frac{v_i + v_f}{2}$ *to find* $\bar{v}$.

Memorize this equation; it is not given on the reference table.
Substitute 16 m/s (meters per second) given *for* v_i (initial or starting speed). *Substitute 0 m/s for* v_f (final speed or speed at the end). An object at rest or brought to rest (example: car brought to rest) has zero speed or zero velocity (object is not moving). *Substitute 4.0 s (seconds) for t* (time).

$$\bar{v} = \frac{v_i + v_f}{2}$$

$$\bar{v} = \frac{16\ m/s + 0\ m/s}{2} = 8\ m/s$$

In the equation $\bar{v} = \frac{d}{t}$, *then substitute for* $\bar{v}$ 8 m/s (from above).

Substitute for t 4.0 s

8 m/s = $\frac{d}{4.0\ s}$	Or, rearrange the equation
	d = $\bar{v}$ t
Cross multiply	
8 m/s x 4.0 s = d	d = 8 m/s x 4.0 s
d = 32 m	d = 32 m
d (distance, how far) = 32 m	d (distance, how far) = 32 m
Answer *1*	Answer *1*

Note: You will learn later that you can also use the equation $d = v_i t + 1/2at^2$ to find distance.

$\bar{v} = \frac{d}{t}$ CAN ALSO BE USED TO FIND DISTANCE AND TIME.

You can find time (t) if velocity/speed (v) and distance (d) are given.
You can find distance (d) if velocity/speed (v) and time (t) are given.

Question: A baseball pitcher throws a fastball at 42 meters per second. If the batter is 18 meters from the pitcher, approximately how much time does it take for the ball to reach the batter?
Show all work, including the equation and substitution with units.

Solution: Write down what is given and what you need to find.

Given: pitcher throws a fastball 42 meters per second (it means v (speed) = 42 m/s (meters per second)).
batter is 18 meters from pitcher (it means distance (d) is 18 m (meters))

Find: time (t)

Since speed (v) and distance (d) are given, and the question asks you to find time (t), *look for an equation* below or on Reference Table: Mechanics, on pages reference tables 22-23,that has v (speed), t (time), and d (distance).

Use the equation

$\bar{v} = \frac{d}{t}$

d = displacement/distance
t = time interval
$\bar{v}$ = average velocity/average speed

In the equation $\bar{v} = \frac{d}{t}$, *then substitute for* $\bar{v}$ 42 m/s (given).

Substitute for d 18 m (meters) (given).

Table: Mechanics

$$42\ m/s = \frac{18\ m}{t}$$

Cross multiply
42 m/s t = 18 m
t = 0.43 s

Or, rearrange the equation

$$t = \frac{d}{v}$$

$$t = \frac{18\ m}{42\ m/s}$$

t = 0.43 s

Rule: When a question asks for substitution with units, include units when substituting in the equation and also in the final answer (see question above). Example: $t = \frac{d}{v}$, $t = \frac{18\ m}{42\ m/s}$, t = 0.43 s

Now do Homework Questions #1-7, page 135
(Look for page Chap. 1:135, meaning Chapter 1, page 135)