Current and Circuits

I. Current and Power
   - the ampere

II. Ohm's Law and Resistance
   - the ohm
   - resistors

III. Series and Parallel Circuits
   - applications

	The student will be able to:	HW:
1	Define electric current and the Ampere and solve problems relating current to charge and time. ✓	1 – 3
2	Solve problems involving electric power. ✓	4 – 10
3	Define resistance and the ohm and solve problems using Ohm's Law to relate voltage, current, and resistance. ✓	11 – 23
4	Calculate the effective total resistance for multiple resistors connected in series or parallel and analyze DC circuits consisting of a combination of series and parallel branches of resistors and/or voltage sources, determining voltage and current for each element.	24 – 37

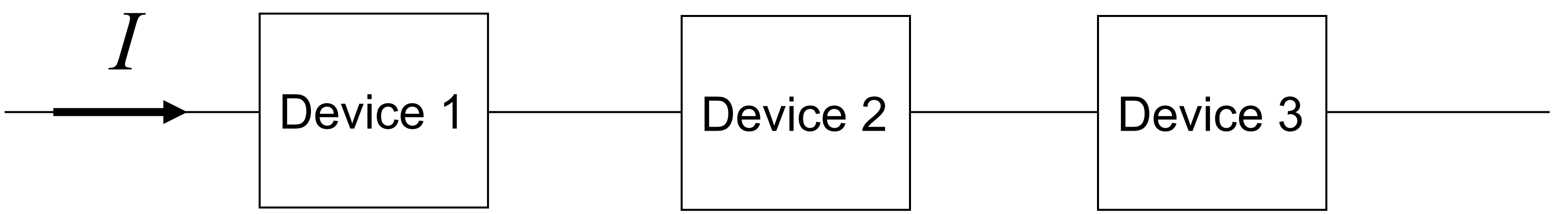
There are primarily two ways to connect electrical devices: **series** and **parallel**.

The behavior of a circuit is dependent upon the type of connections within it. There are important applications of both series and parallel circuits.

In many ways the two types of circuit connections are "opposites" or "inverses" of one another.

Series Connections

Electrical devices are connected in sequence, linked by conductors, so that current proceeds through the devices in a particular order.

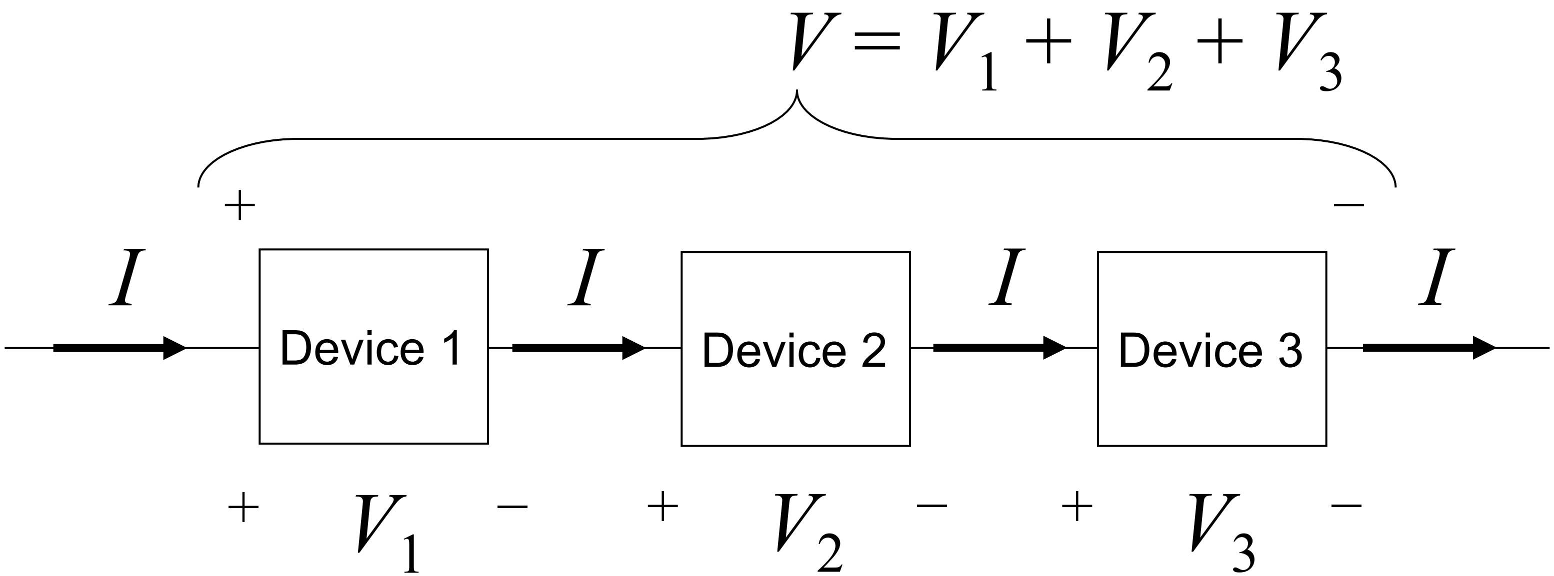


Key characteristics:

The **current** is the same through each device.

The **voltage** across any set of devices in series is equal to the sum of the voltages across each device in the set.

Series Connections



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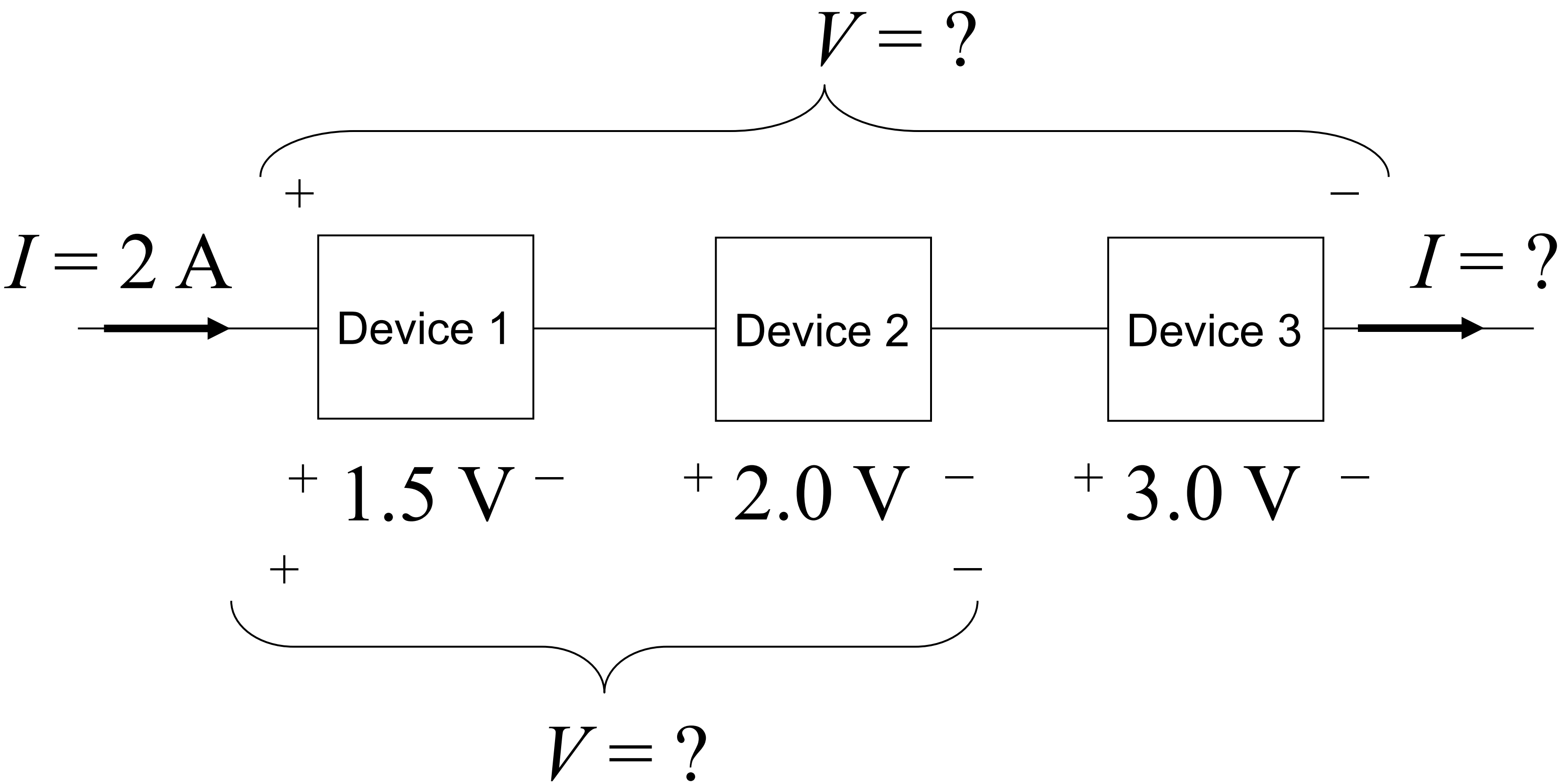
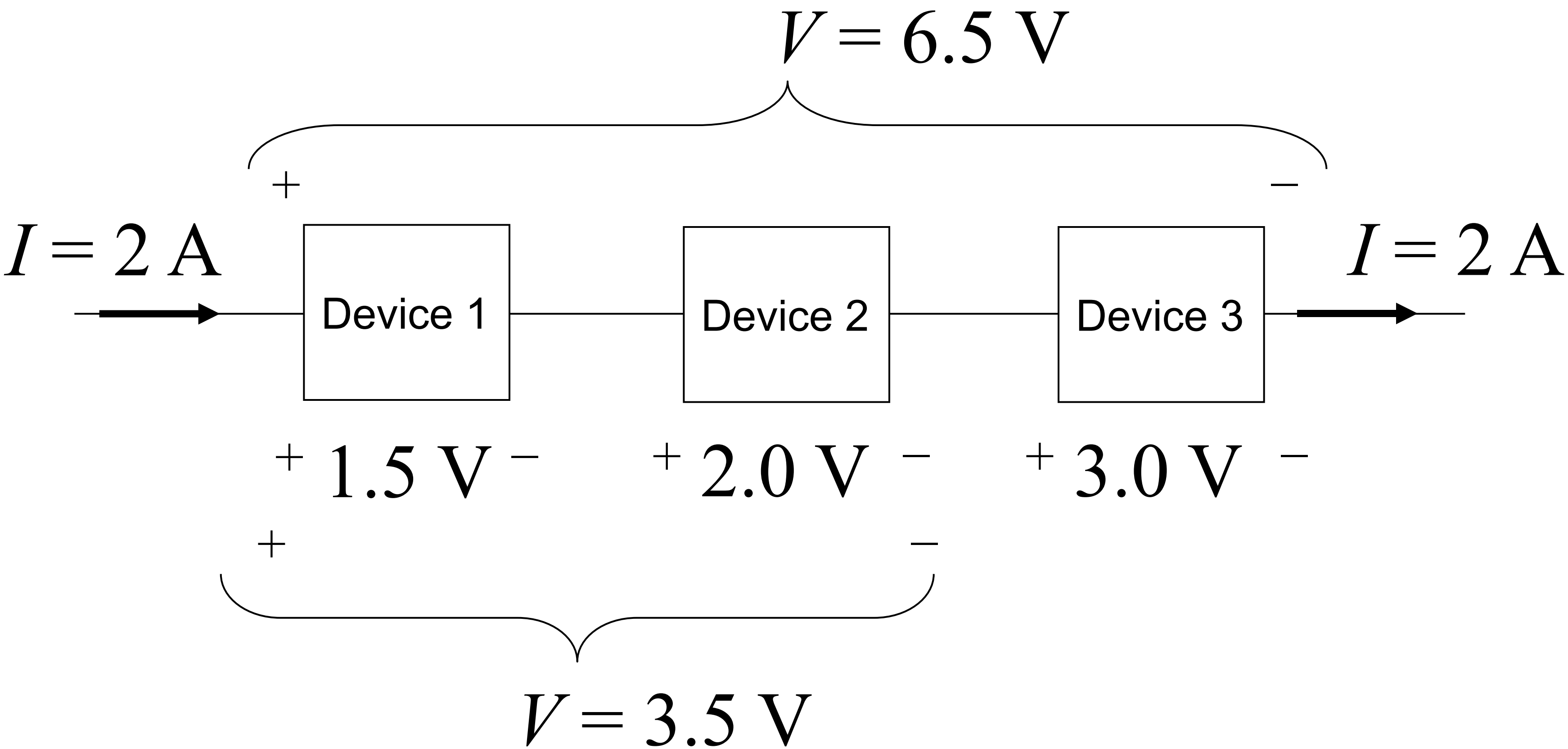
Series Example

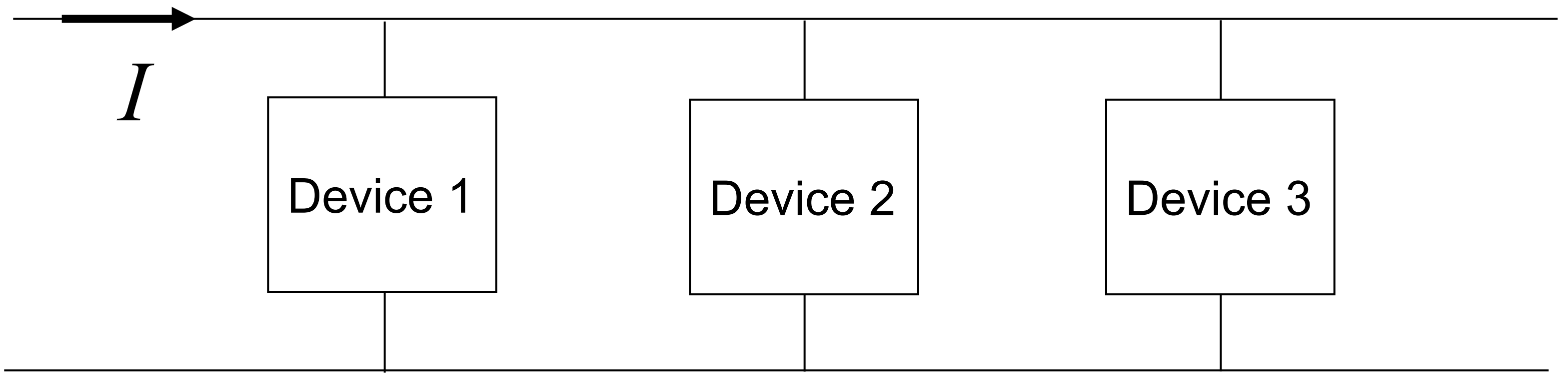


Series Example



Parallel Connections

Electrical devices are connected *between* two conductors so that current may branch out and proceed through the devices simultaneously.

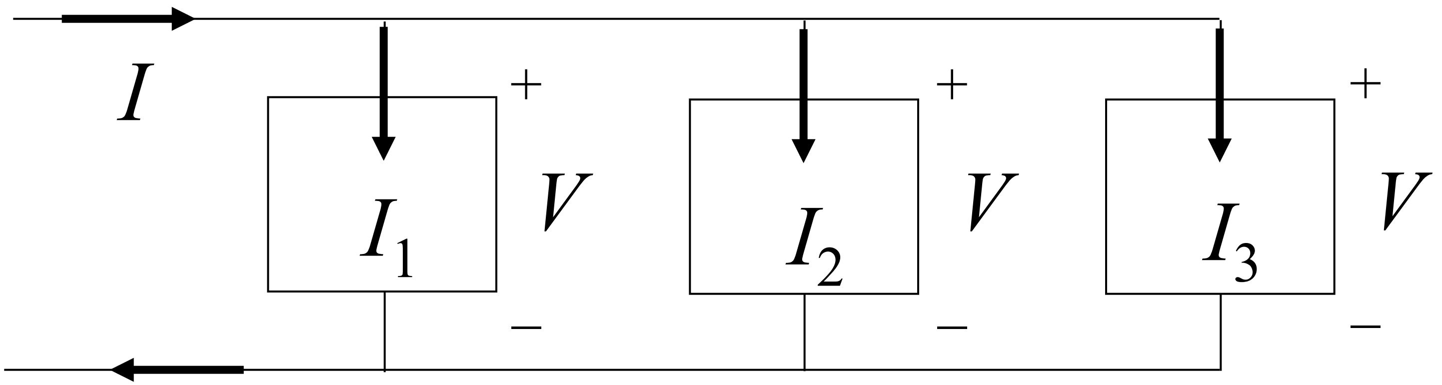


Key characteristics:

The **voltage** is the same across each device.

The **current** through any set of devices in parallel is equal to the sum of the currents through each device in the set.

Parallel Connections

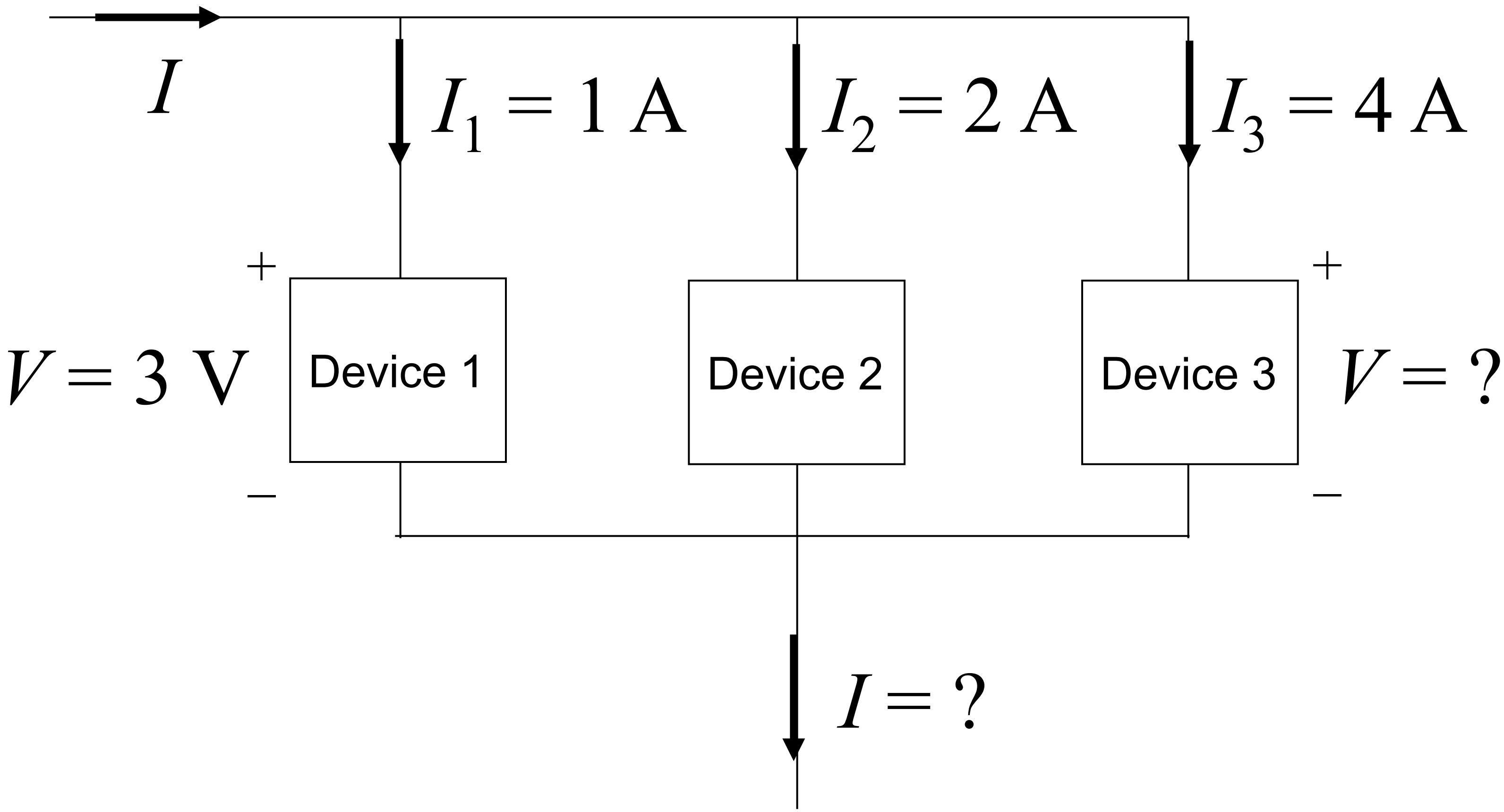


$$I = I_1 + I_2 + I_3$$

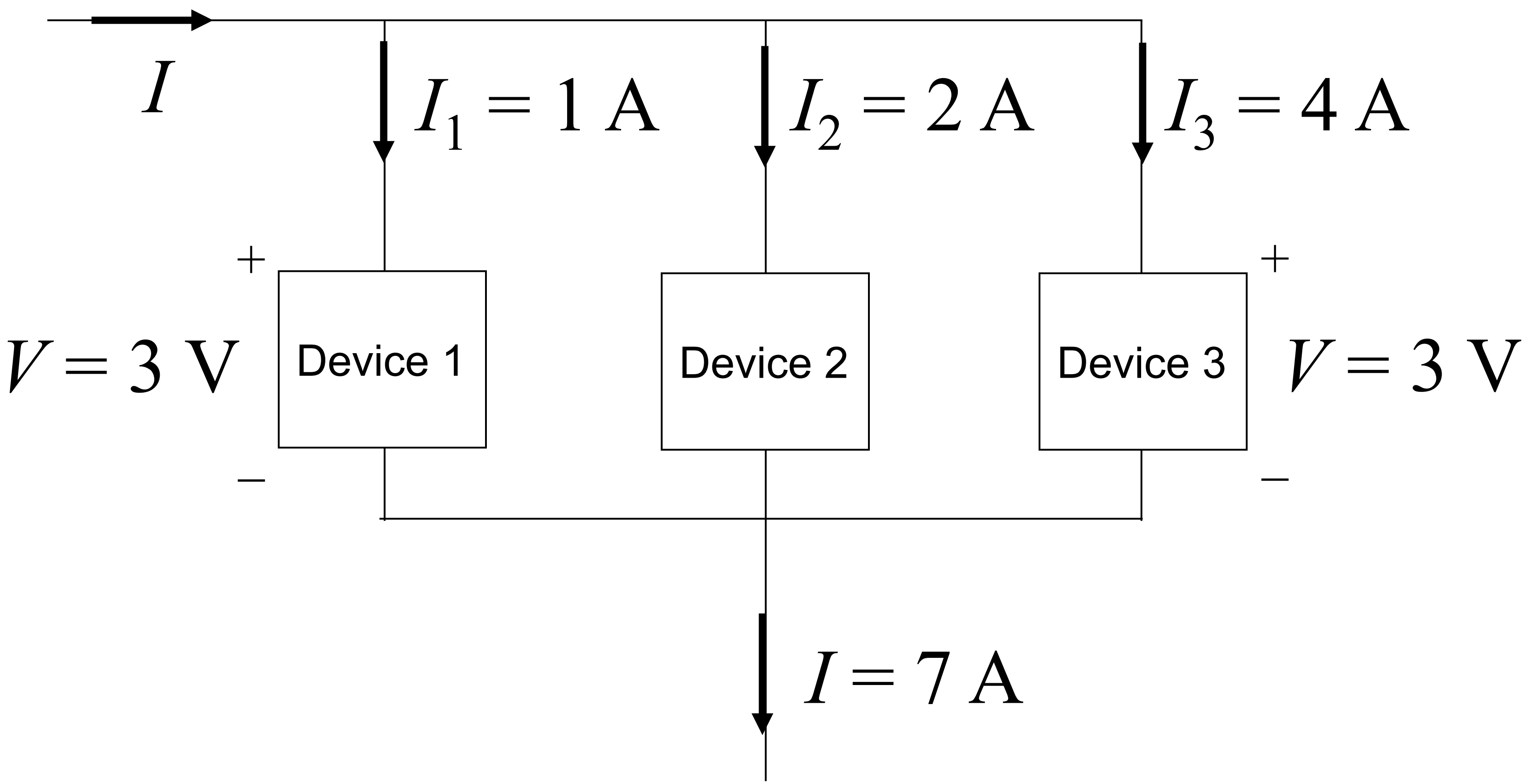
The **voltage** is the same across each device.

The **current** through any set of devices in parallel is equal to the sum of the currents through each device in the set.

Parallel Example



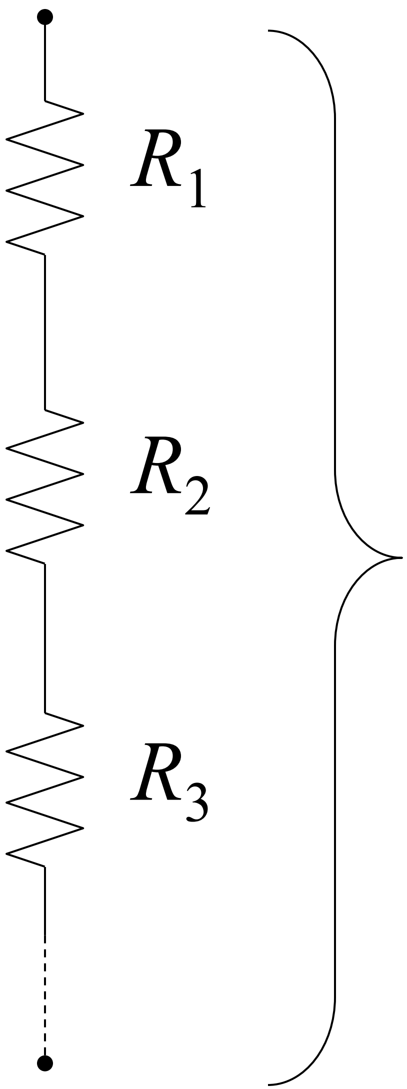
Parallel Example



Resistor Combinations

- Multiple resistors may be connected in series or parallel.
- A particular combination of resistors will pose a certain resistance to the flow of charge.
- Any particular resistor combination may be said to have an "effective" or "equivalent" resistance of a certain number of ohms.

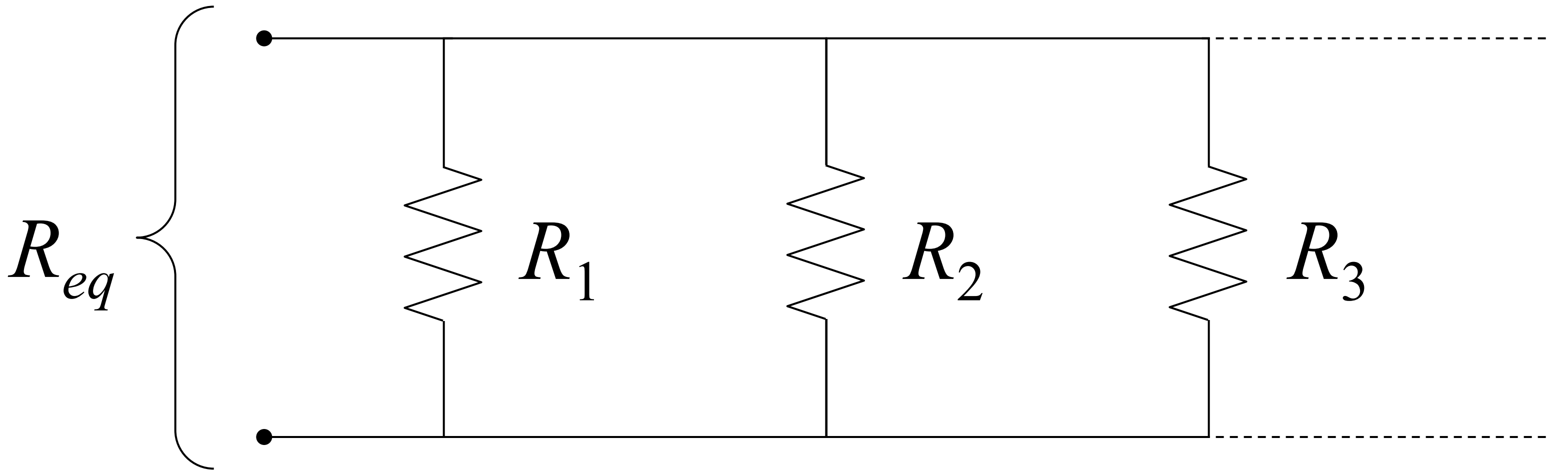
Equivalent Resistance of Series Resistors



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

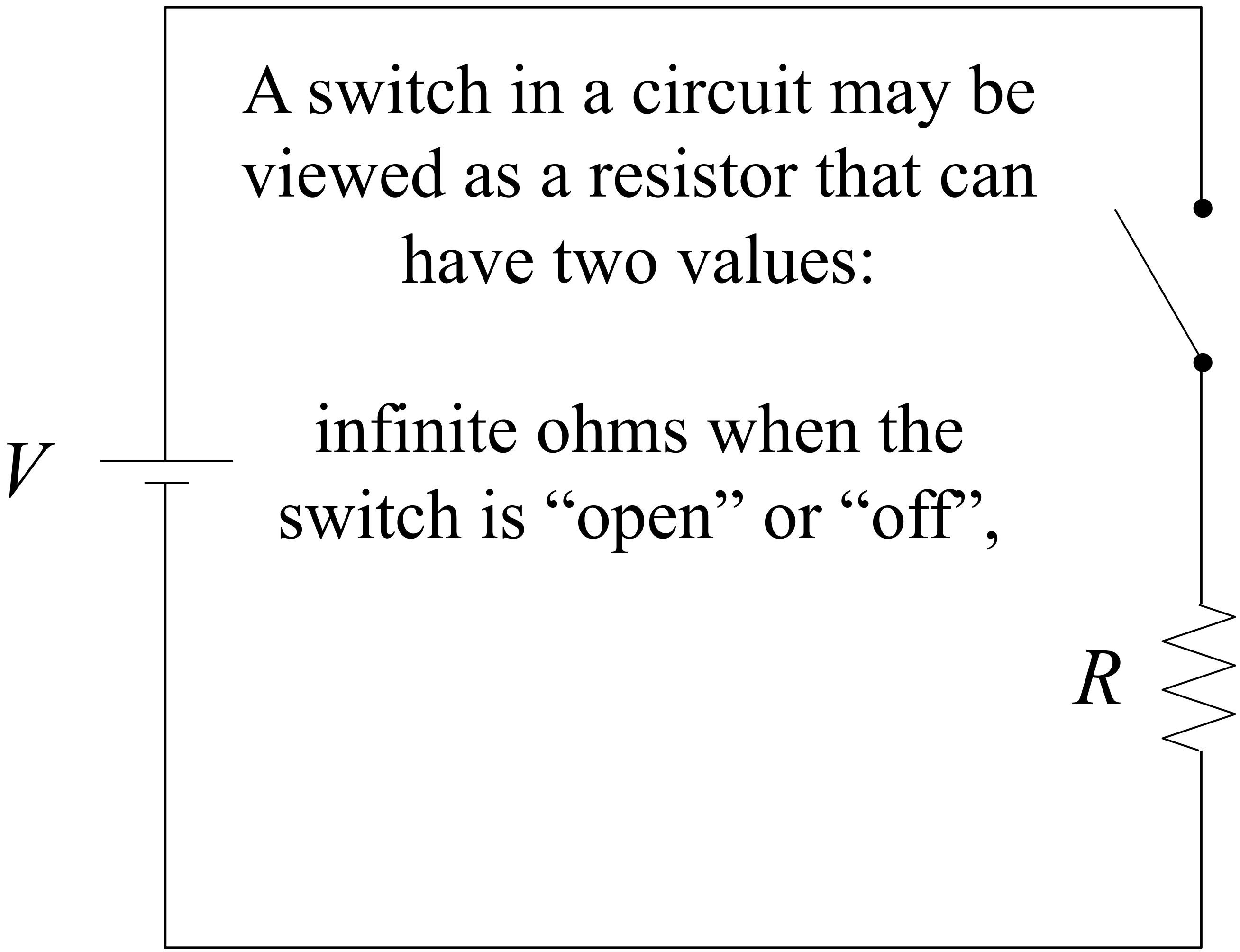
The equivalent resistance is *greater* than that of any single resistor in the set.

Equivalent Resistance of Parallel Resistors



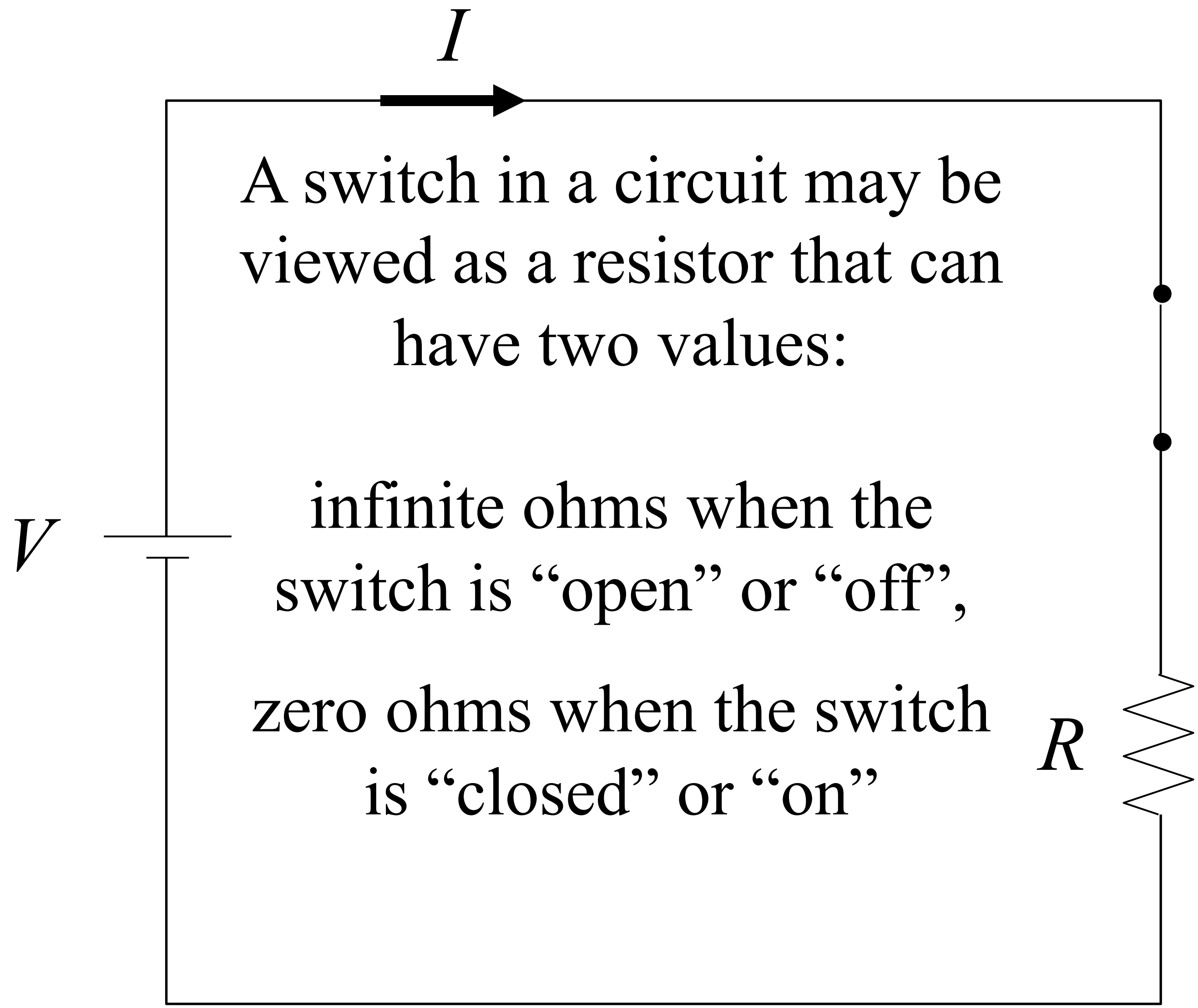
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$$

The equivalent resistance is *less* than that of any single resistor in the set.



A switch in a circuit may be viewed as a resistor that can have two values:

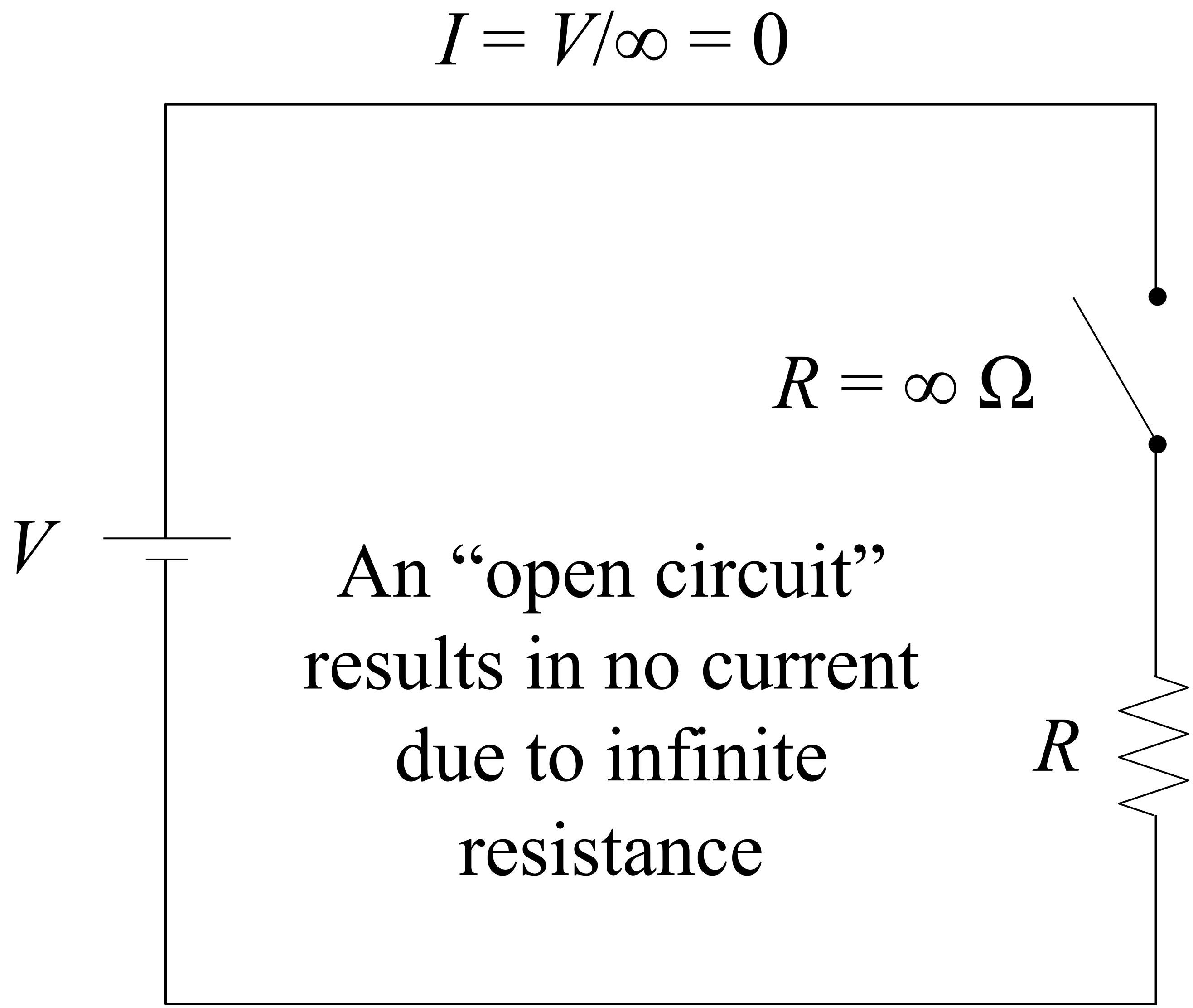
infinite ohms when the switch is “open” or “off”,

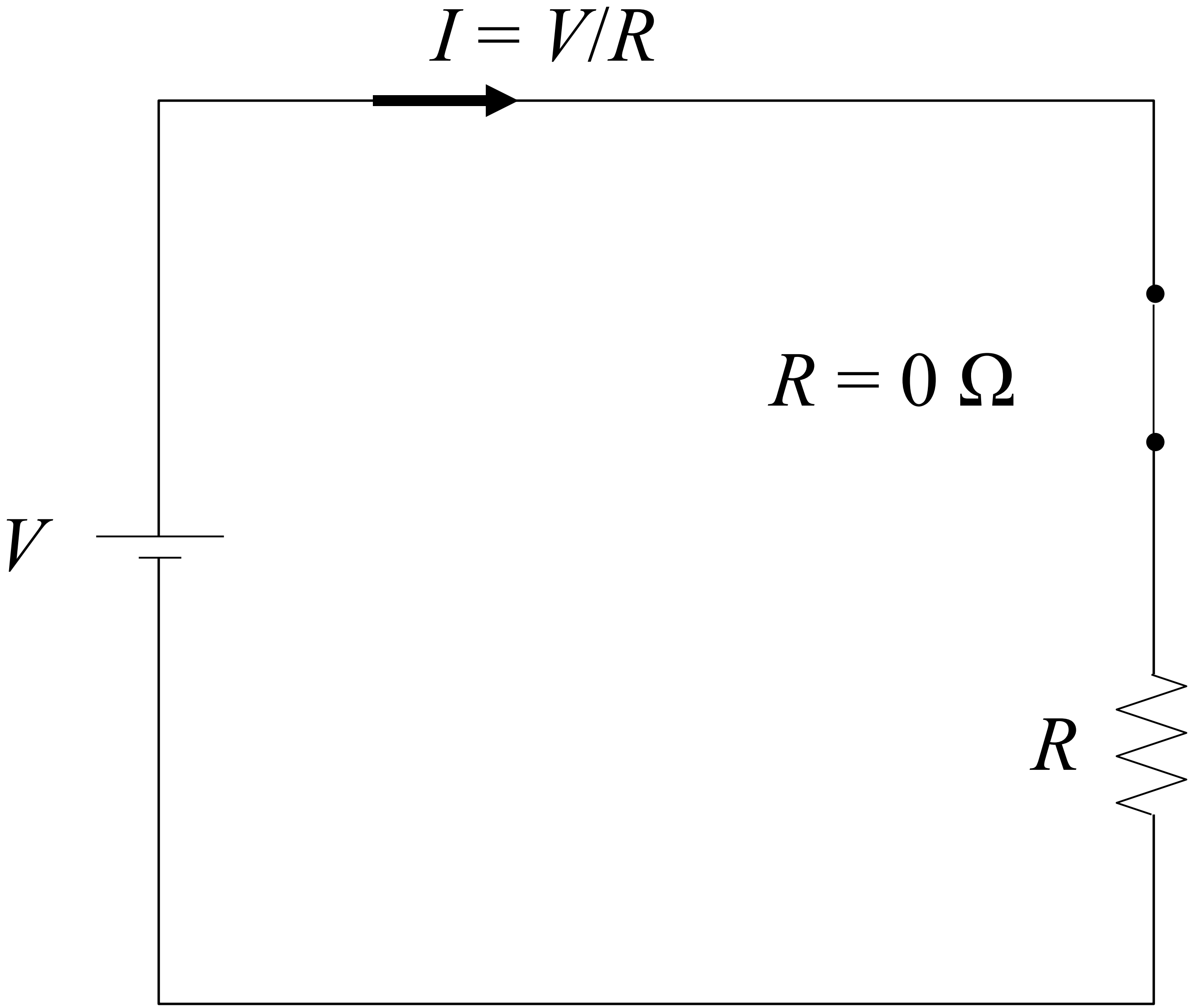


A switch in a circuit may be viewed as a resistor that can have two values:

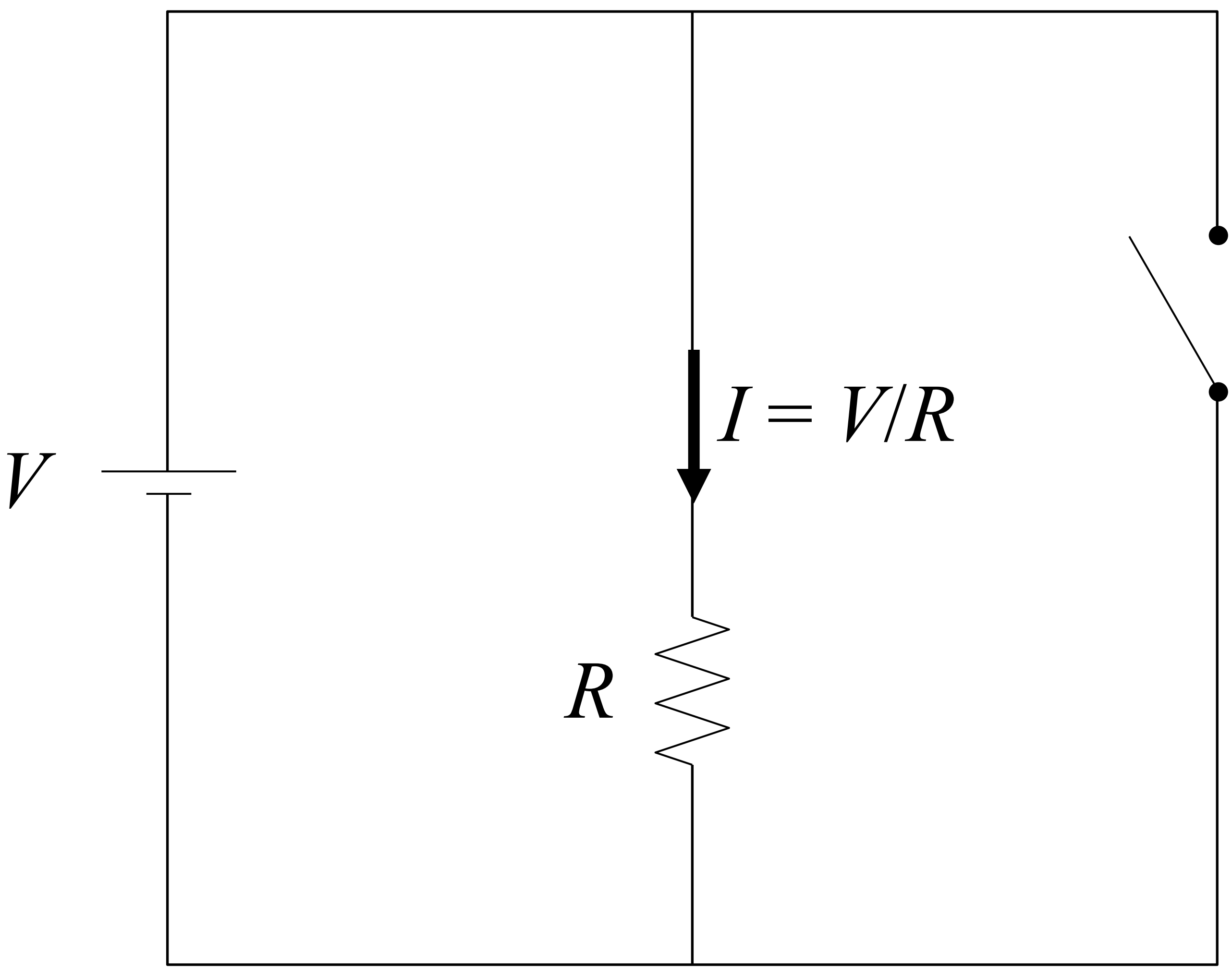
infinite ohms when the switch is “open” or “off”,

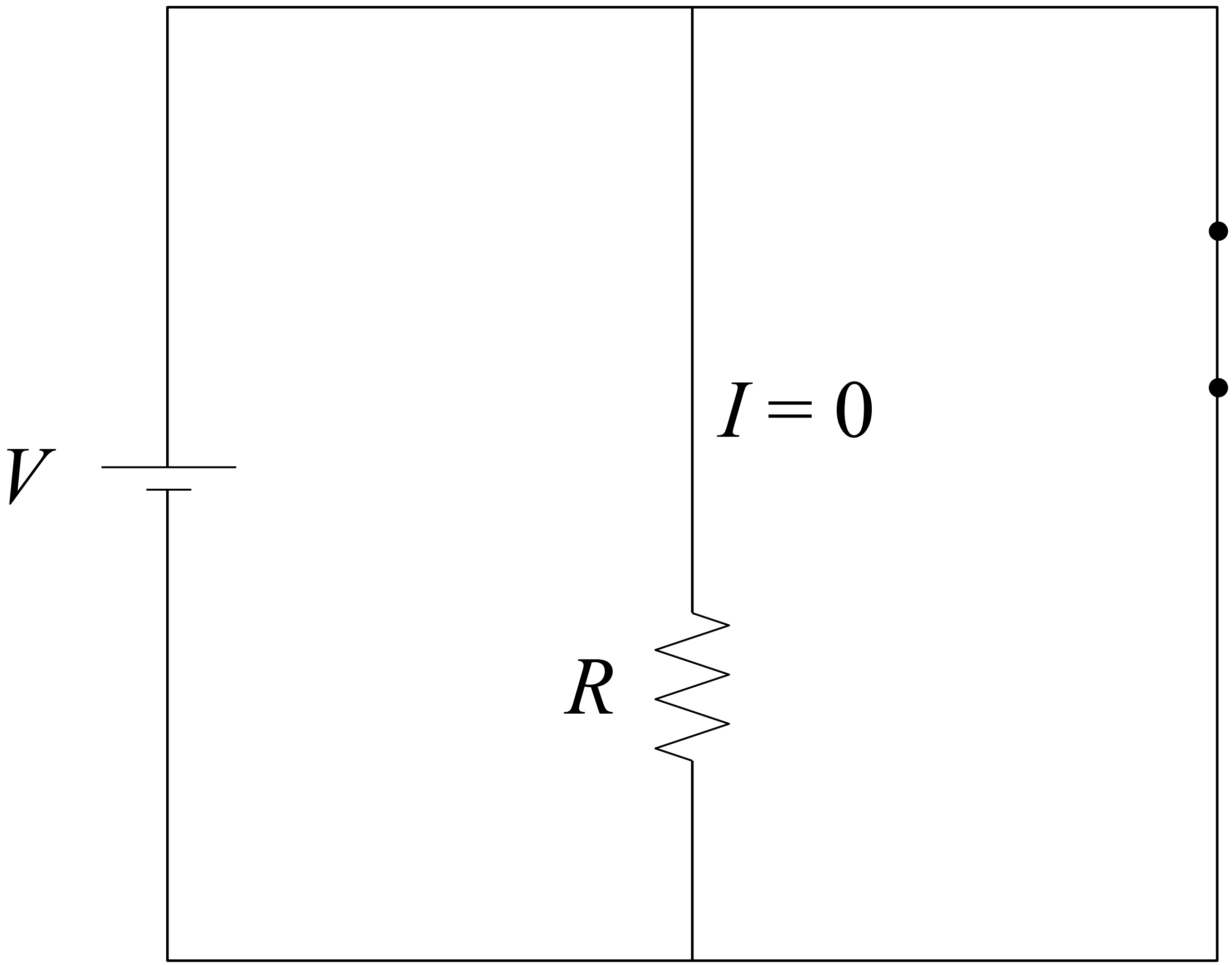
zero ohms when the switch is “closed” or “on”

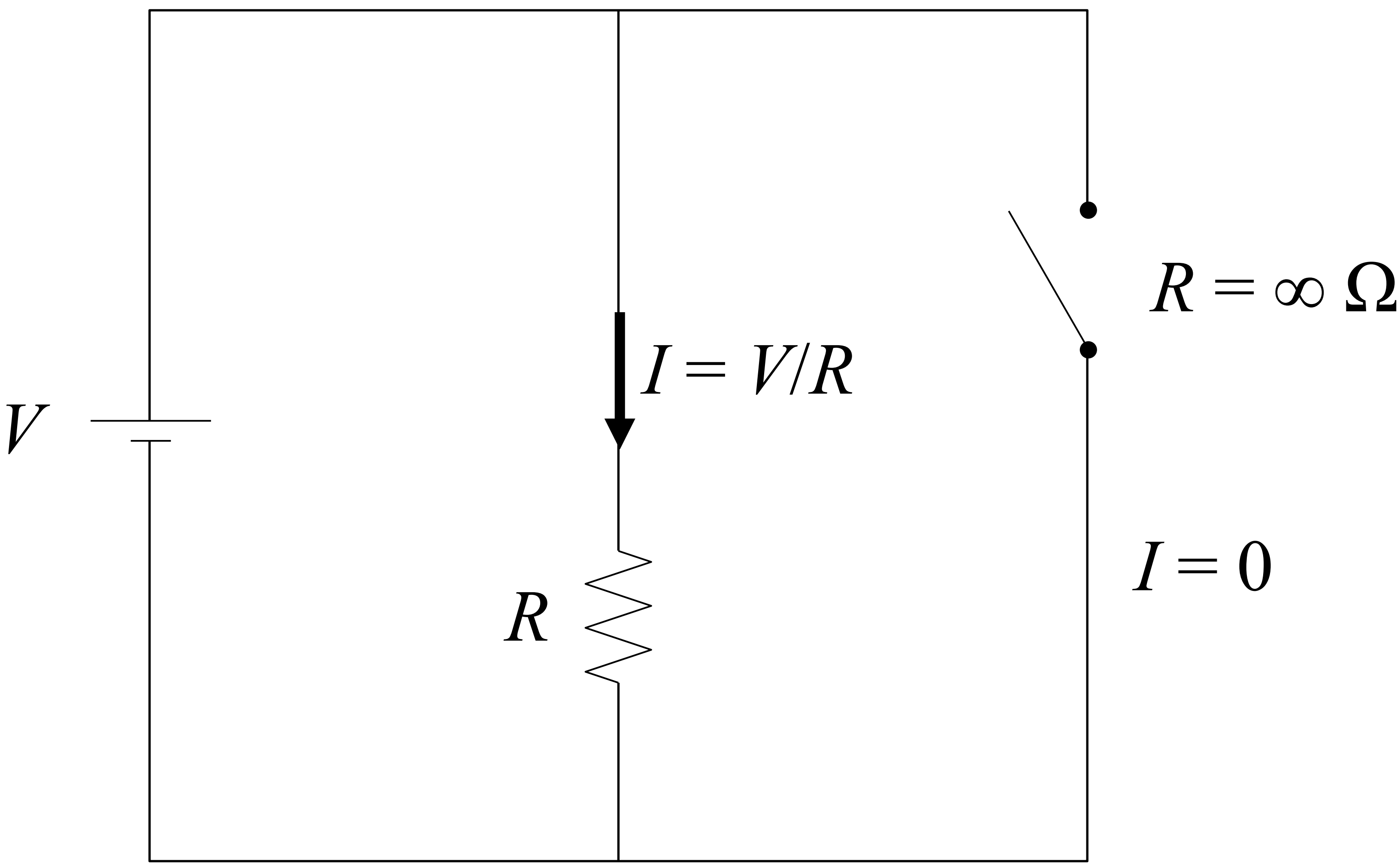

$I = V/\infty = 0$
$R = \infty\ \Omega$
V
An "open circuit" results in no current due to infinite resistance
R



I = V/R
R = 0 Ω
V
R

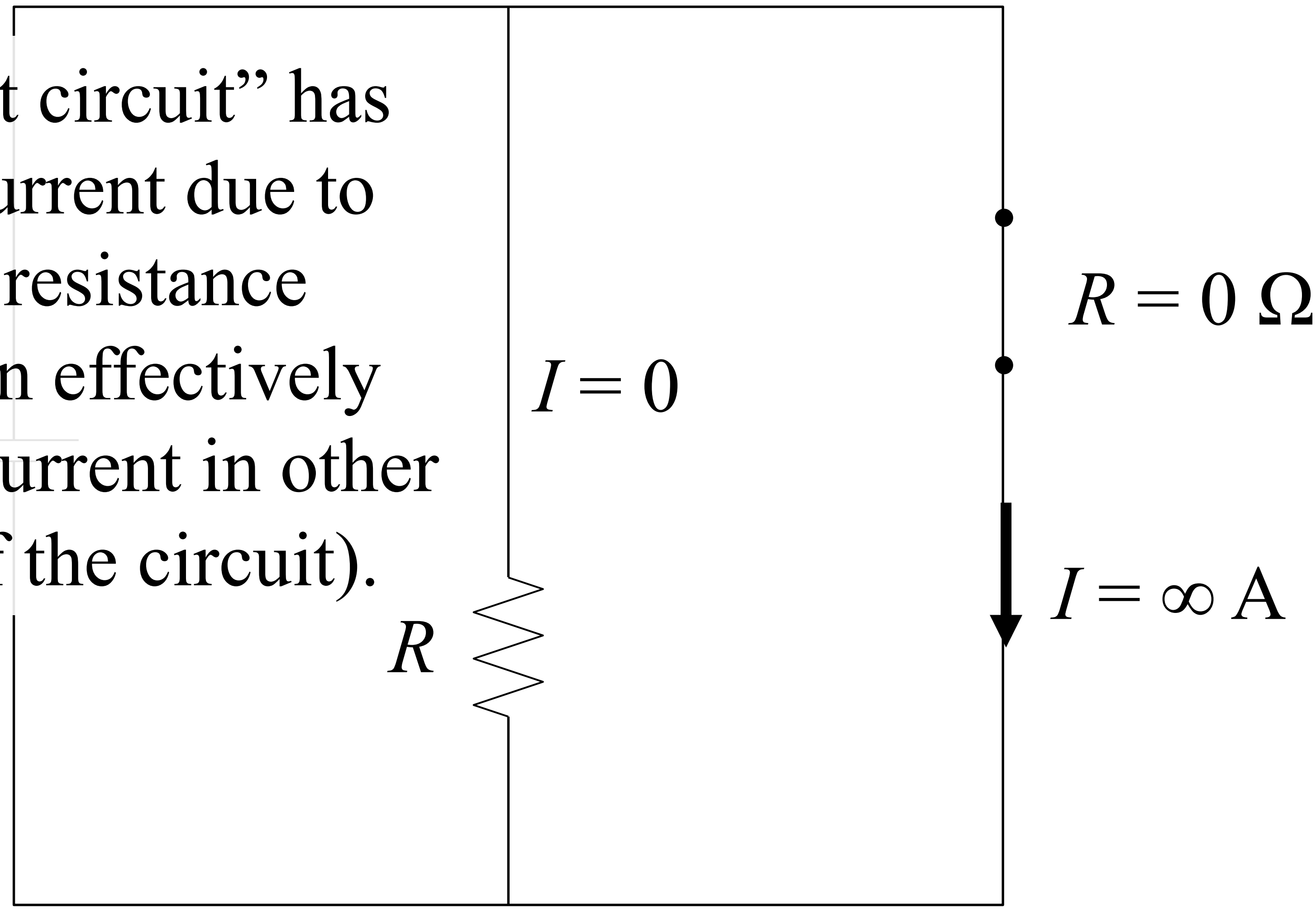

V
I = V/R
R


$I = 0$
V
R

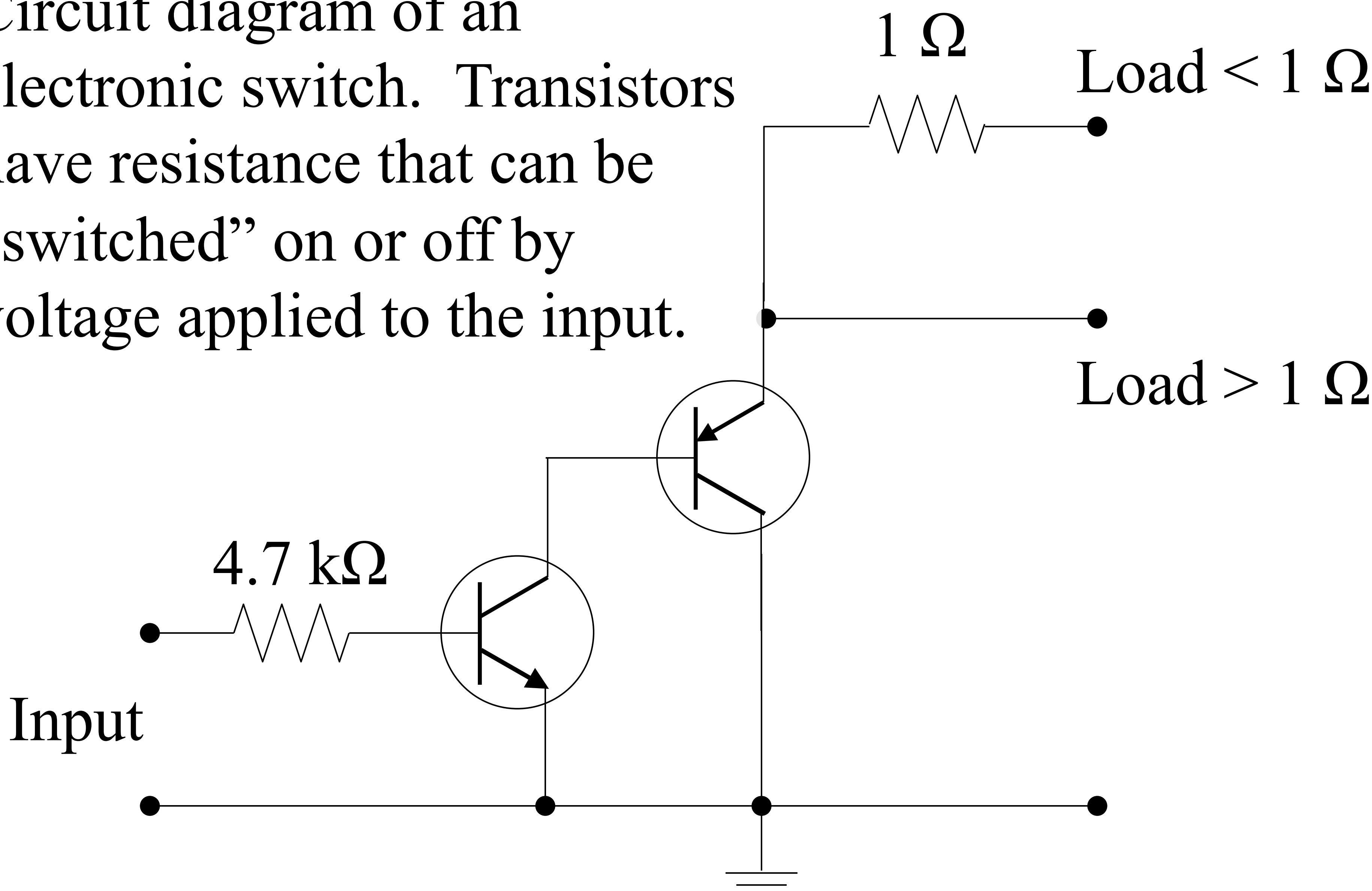


$R = \infty\ \Omega$
$I = V/R$
V
$I = 0$
R

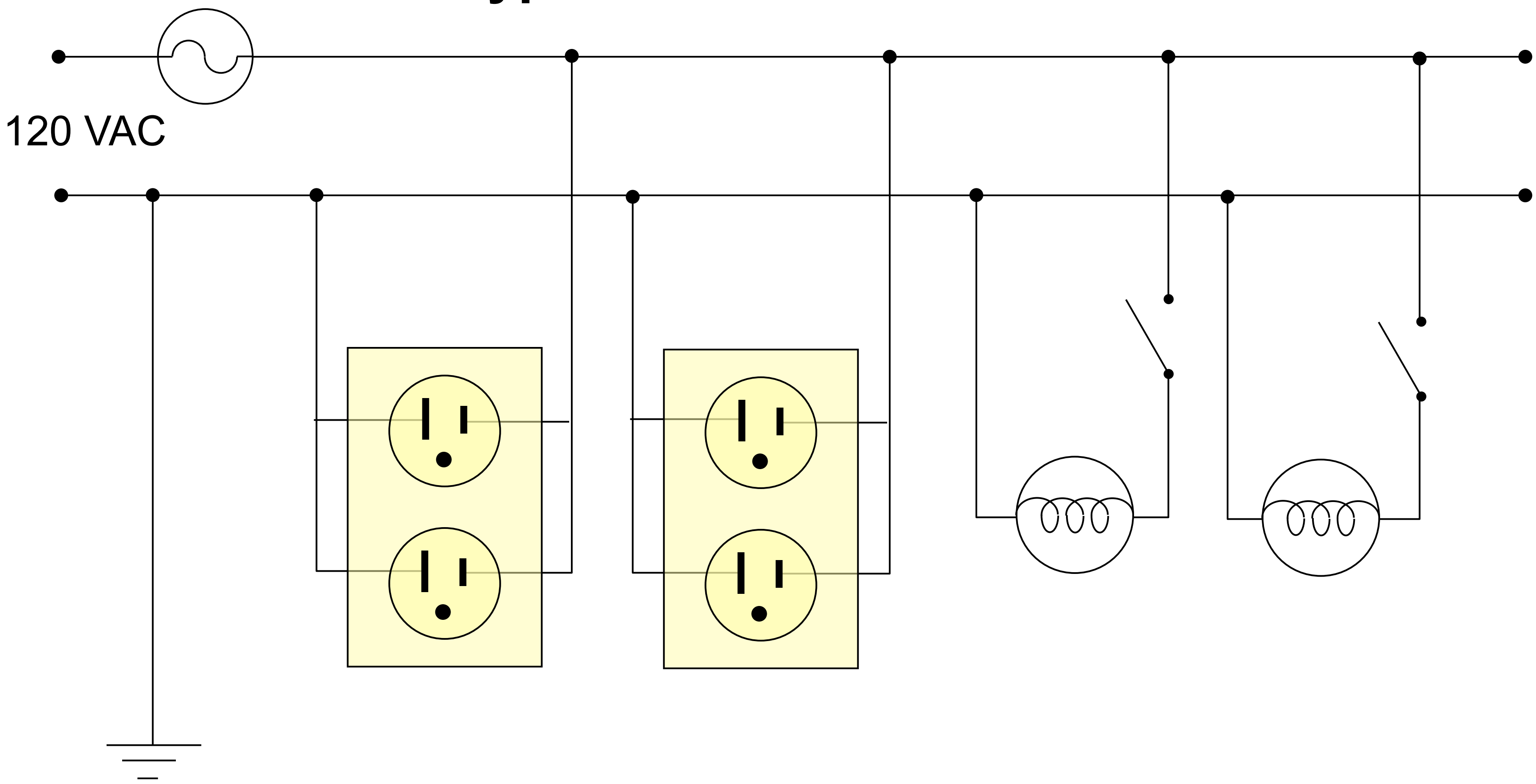
A “short circuit” has large current due to little resistance (and can effectively prevent current in other parts of the circuit).

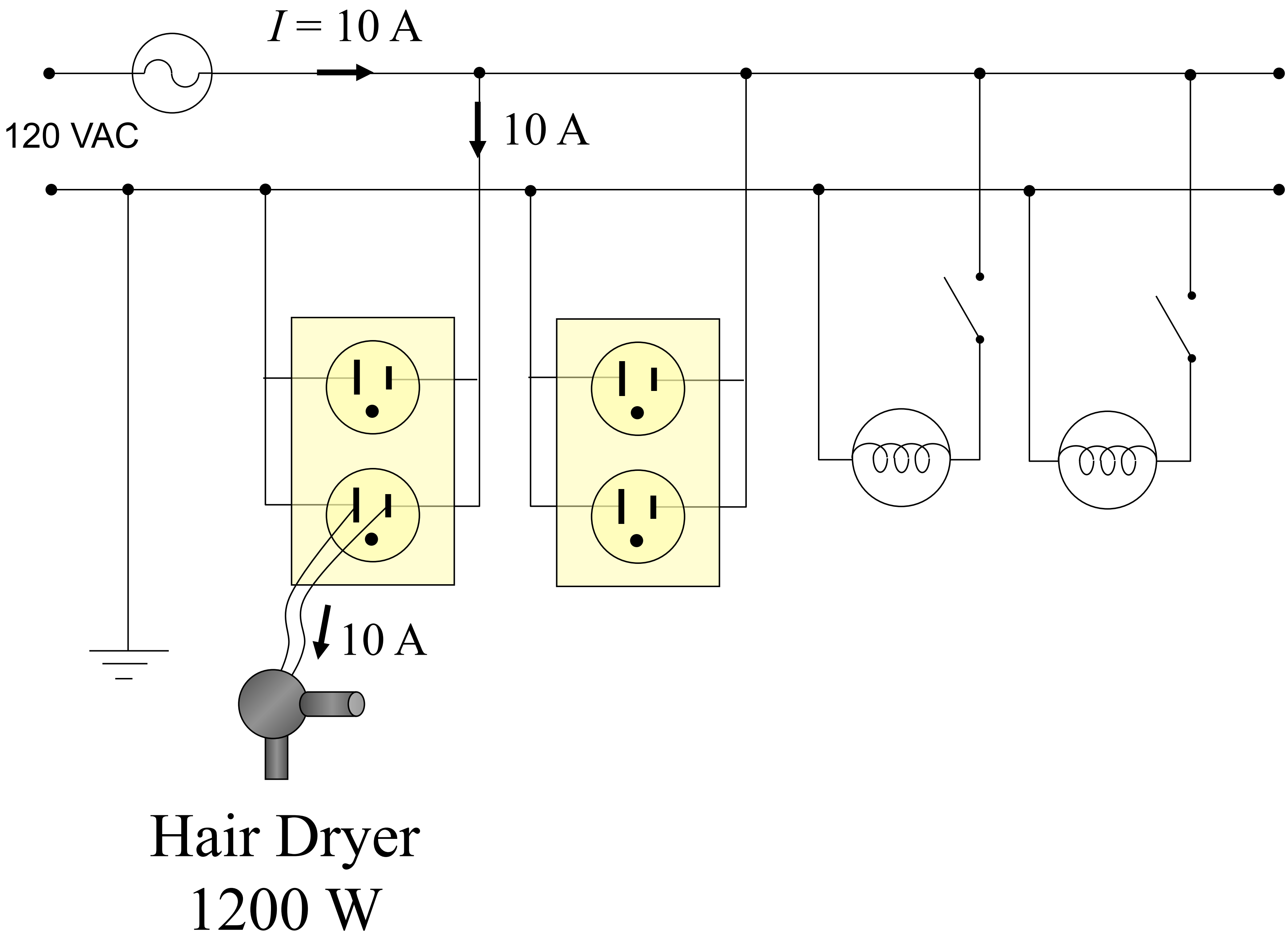


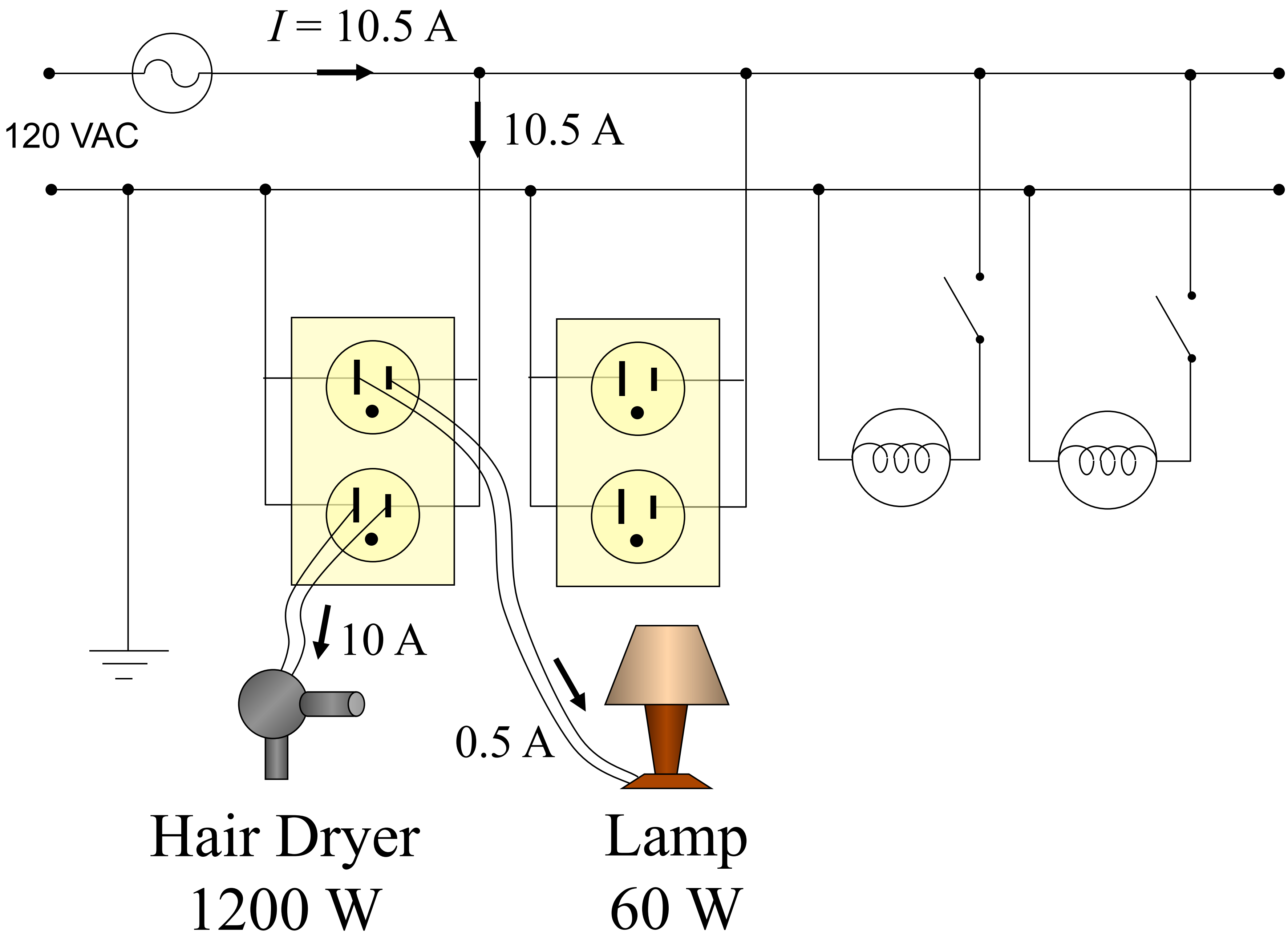
Circuit diagram of an electronic switch. Transistors have resistance that can be "switched" on or off by voltage applied to the input.



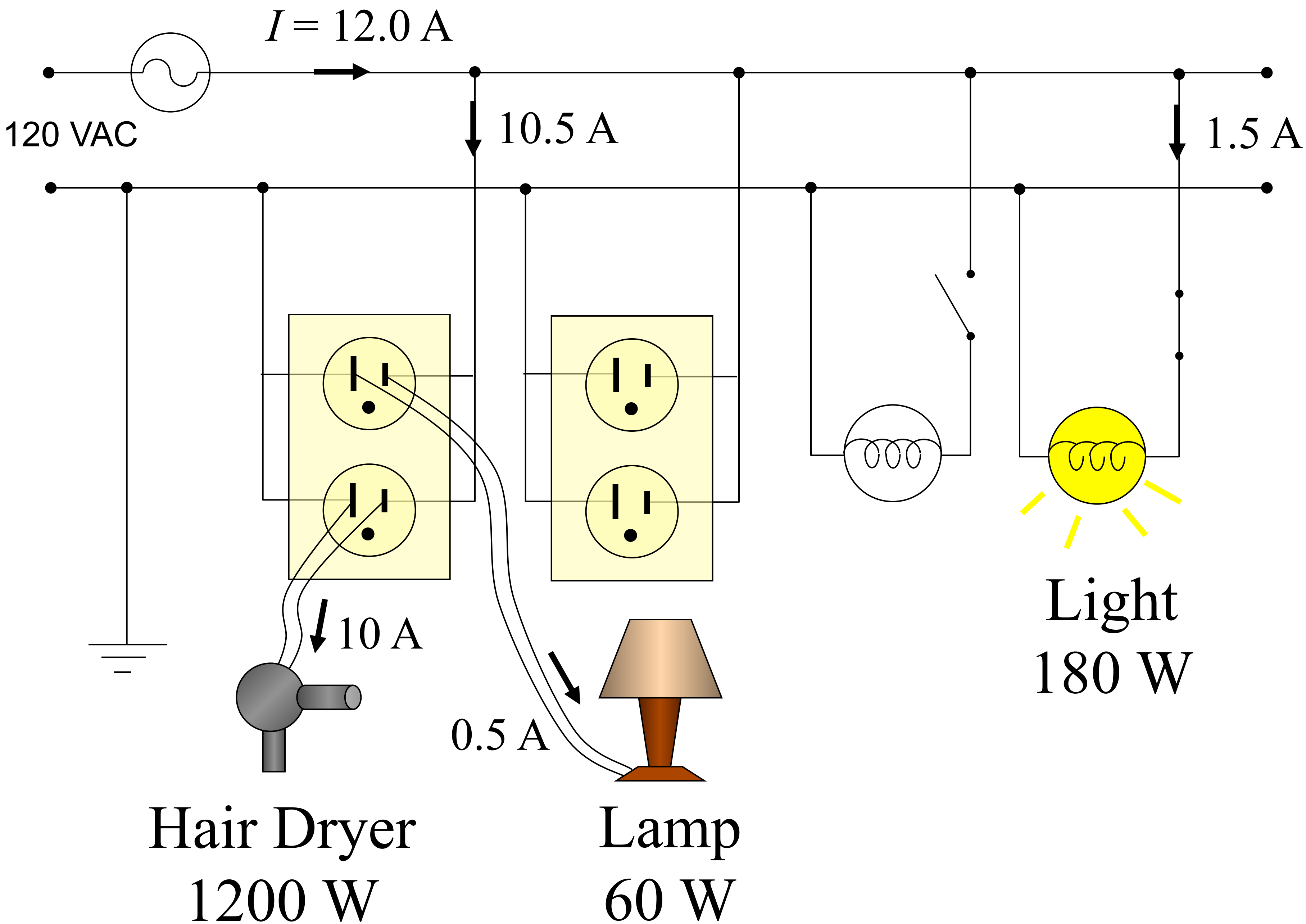
a typical household circuit

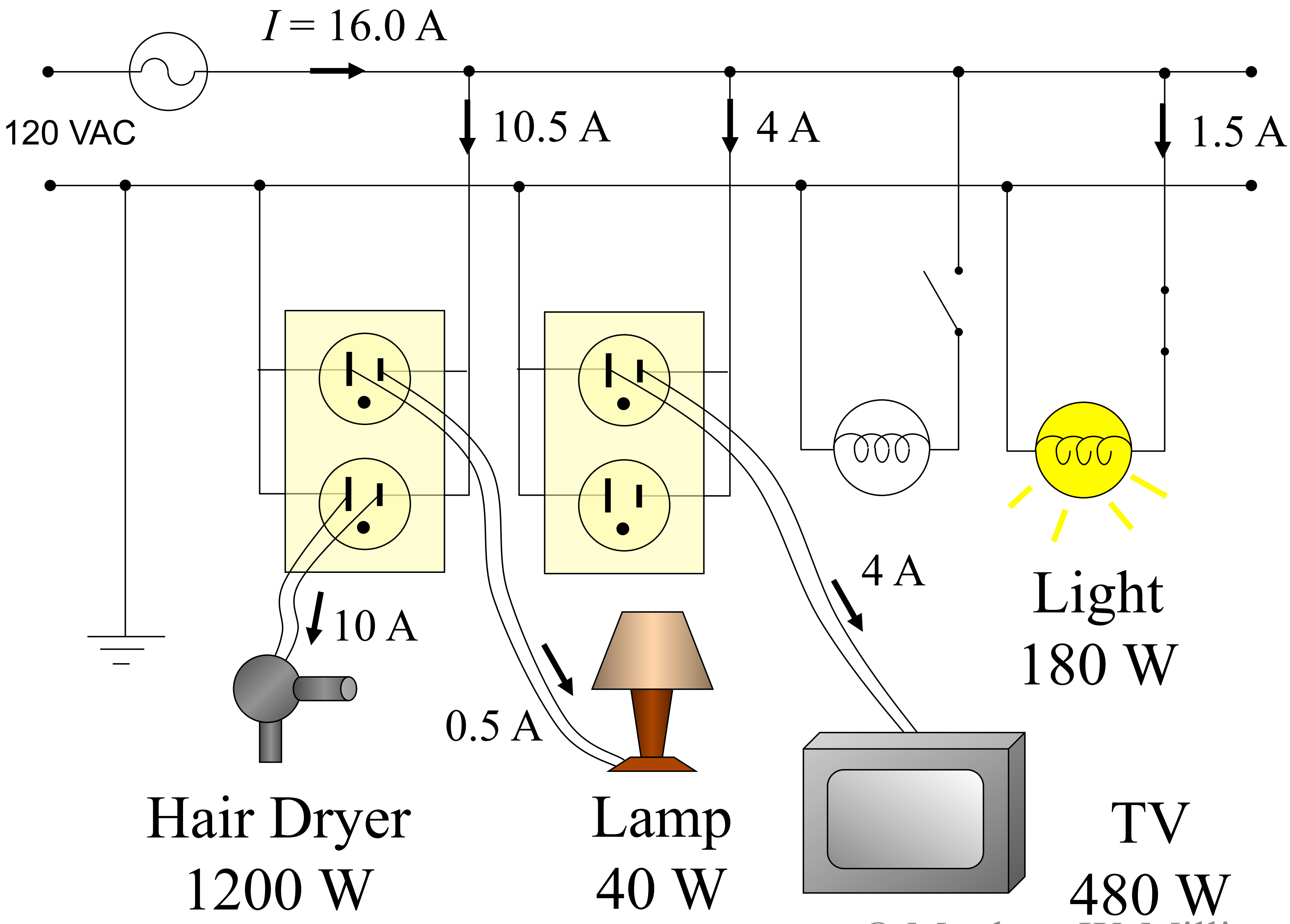



I = 10 A
10 A
120 VAC
10 A
Hair Dryer
1200 W

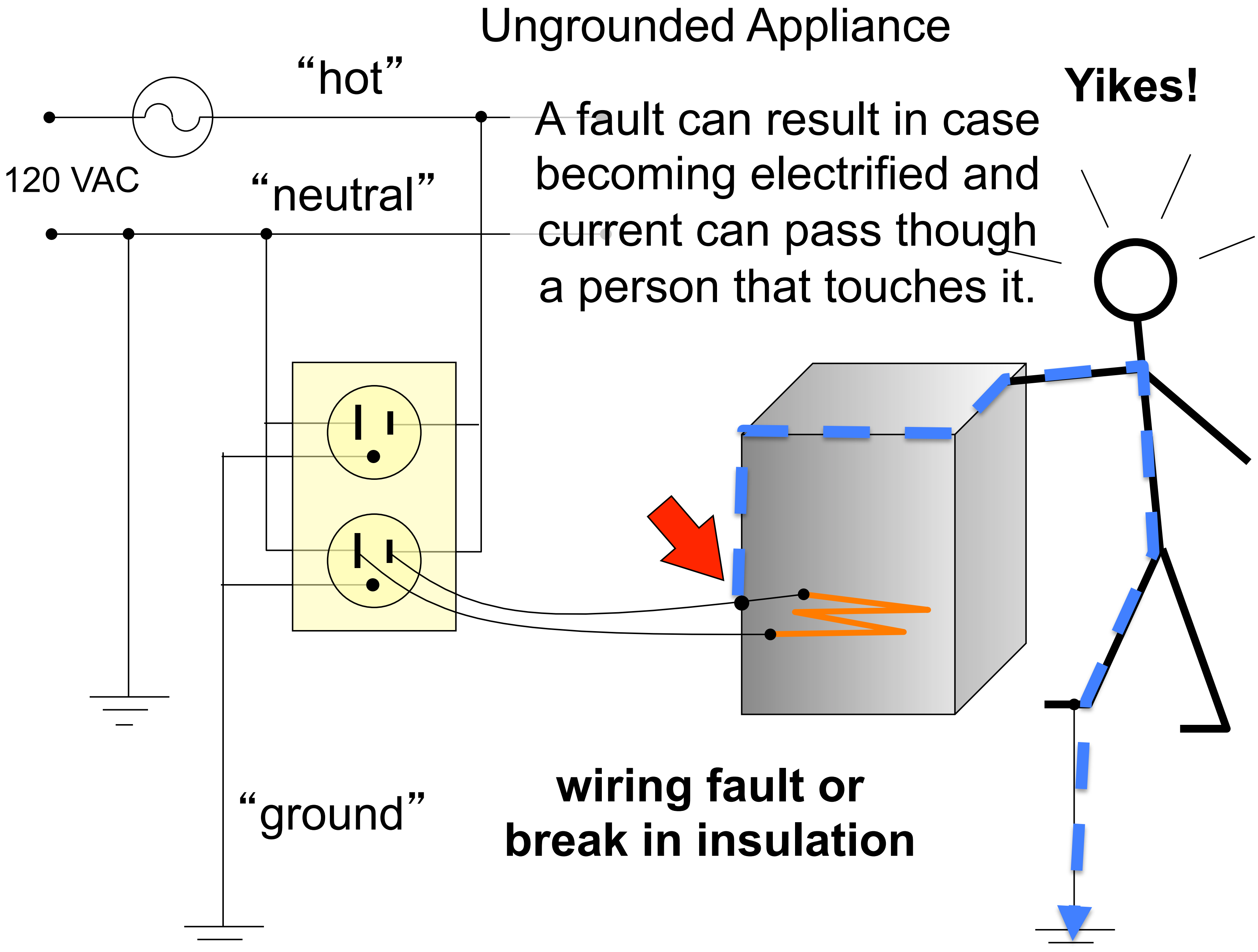


$I = 10.5$ A
120 VAC
10.5 A
10 A
0.5 A
Hair Dryer
1200 W
Lamp
60 W

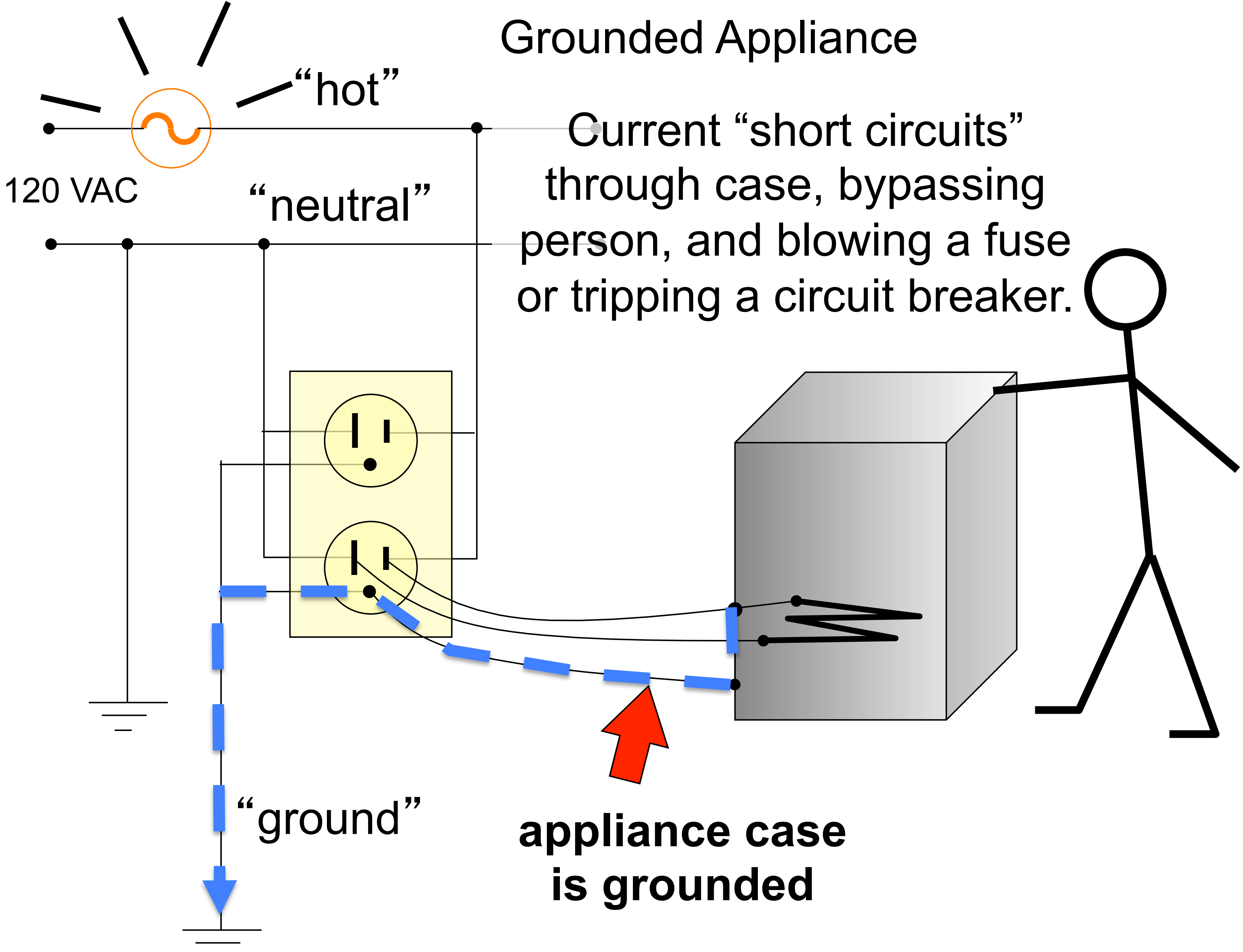

I = 12.0 A
120 VAC
10.5 A
1.5 A
10 A
0.5 A
Hair Dryer
1200 W
Lamp
60 W
Light
180 W

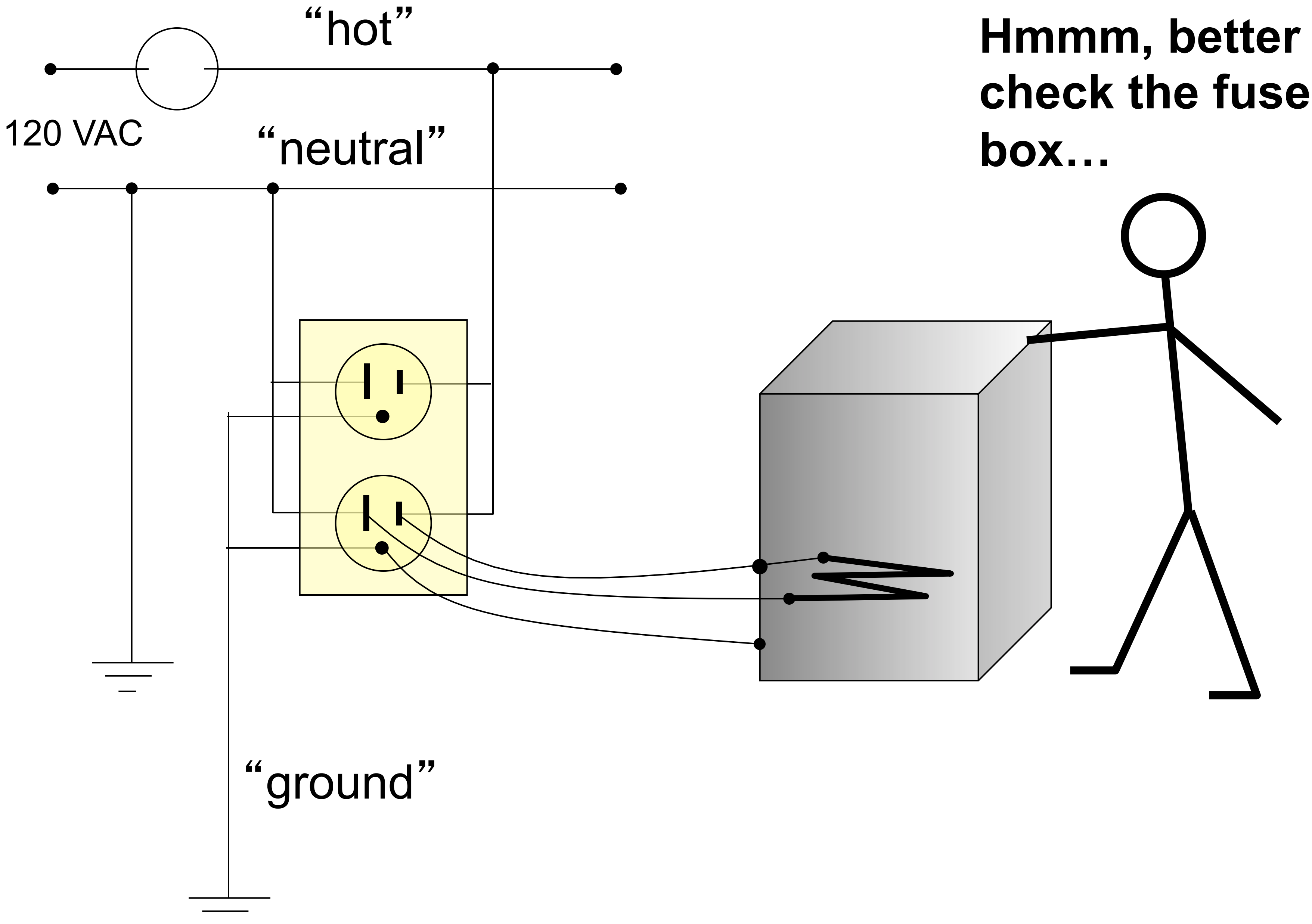


I = 16.0 A
120 VAC
10.5 A
4 A
1.5 A
10 A
0.5 A
4 A
Light
180 W
Hair Dryer
1200 W
Lamp
40 W
TV
480 W


Ungrounded Appliance
"hot"
120 VAC
"neutral"
A fault can result in case becoming electrified and current can pass though a person that touches it.
Yikes!
"ground"
wiring fault or
break in insulation

Grounded Appliance




"hot"
120 VAC
"neutral"
"ground"
Hmmm, better check the fuse box…