# ECE 203 Circuits I

## Lecture 4

## Resistors and Ohm's Law

# $1^{st}$ Circuit Element: Resistor

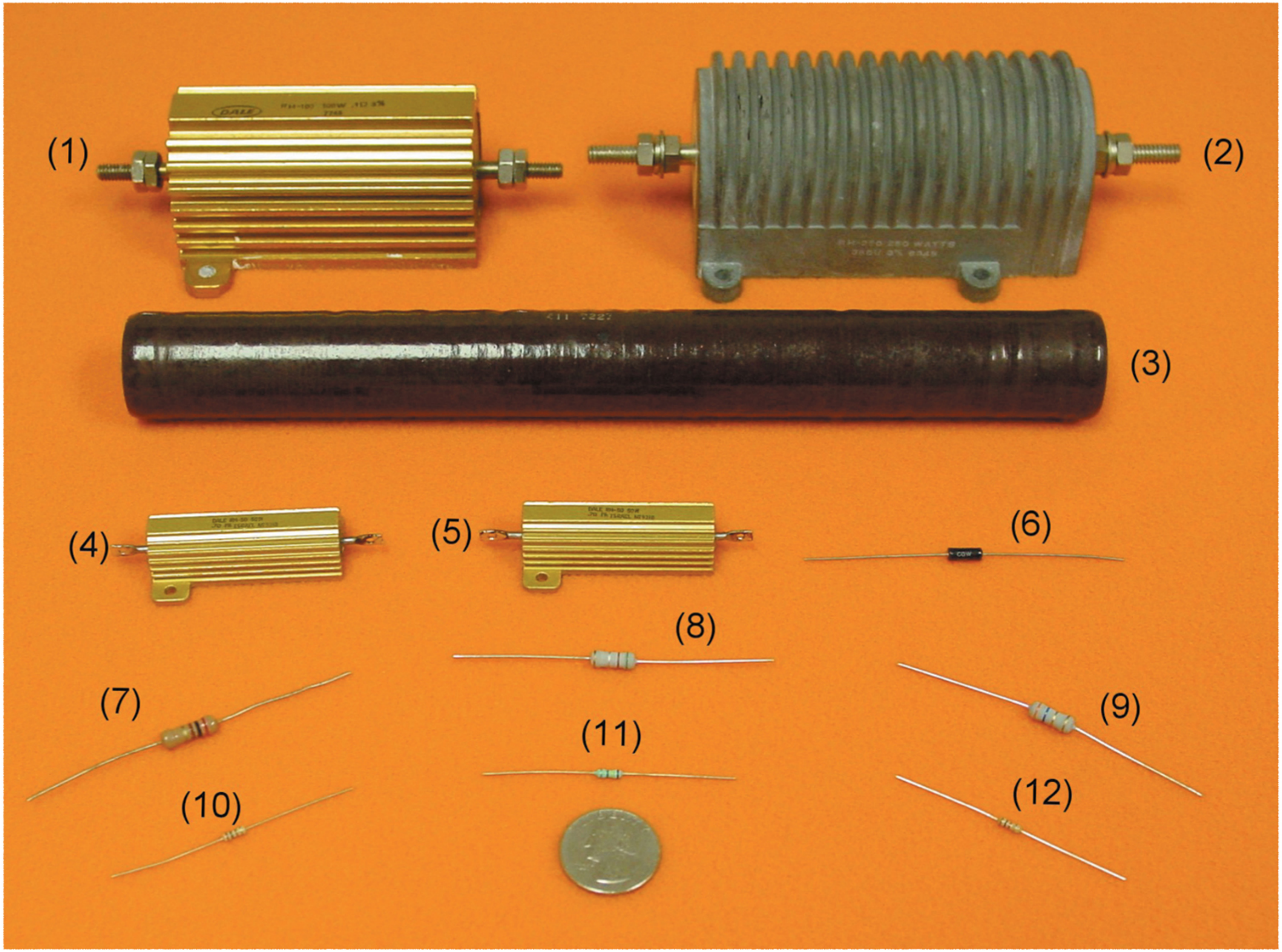
Resistance: The ability of a material to resist the flow of current

Symbol: R

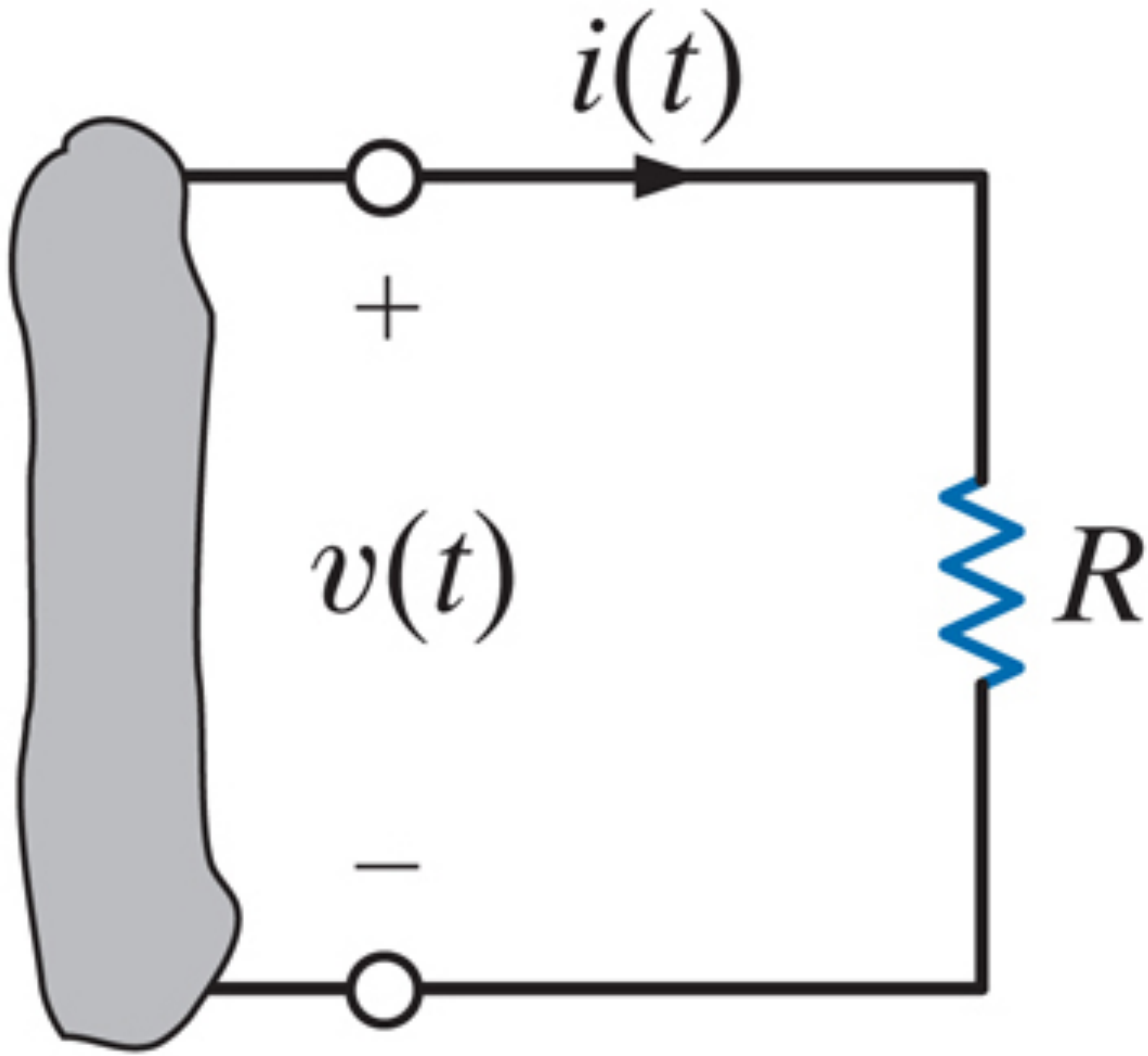
Units: Ohms ($\Omega$)

An insulator has infinite resistance

A conductor has very low resistance



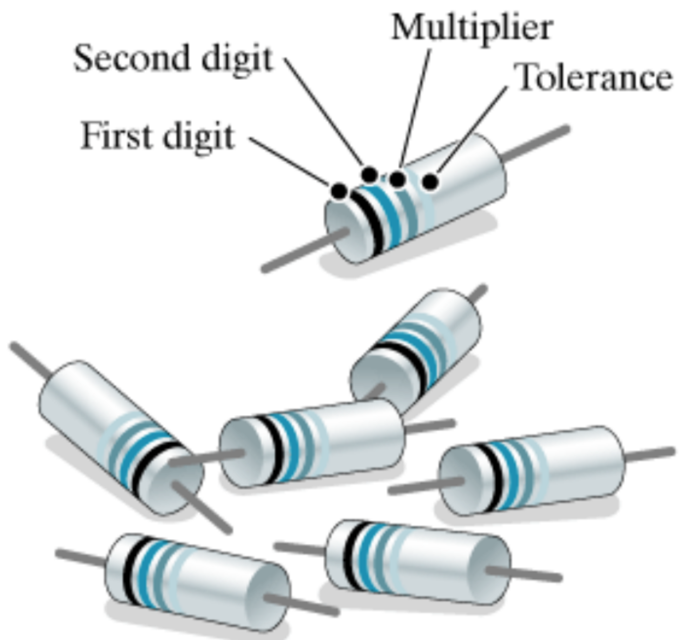

Resistors



i(t)
+
v(t)
−
R

## Practical Perspective: Circuits with Realistic Resistors

Resistors are manufactured for a number of discrete values, and any resistor will vary from its stated value within some tolerance. Resistors with tighter tolerance, say 1%, are more expensive than resistors with greater tolerance, say 10%.




It is important to understand which resistor’s value has the greatest impact on the expected performance of the circuit. In other words, we would like to predict the effect of varying each resistor's value on the output of the circuit.

If we know that a particular resistor must be very close to its stated value for the circuit to function correctly, we can decide to spend the extra money necessary to achieve a tighter tolerance on that particular resistor's value.

Exploring the effect of a circuit component's value on the circuit's output is known as **sensitivity analysis**. We’ll come back to this at the end of this chapter.

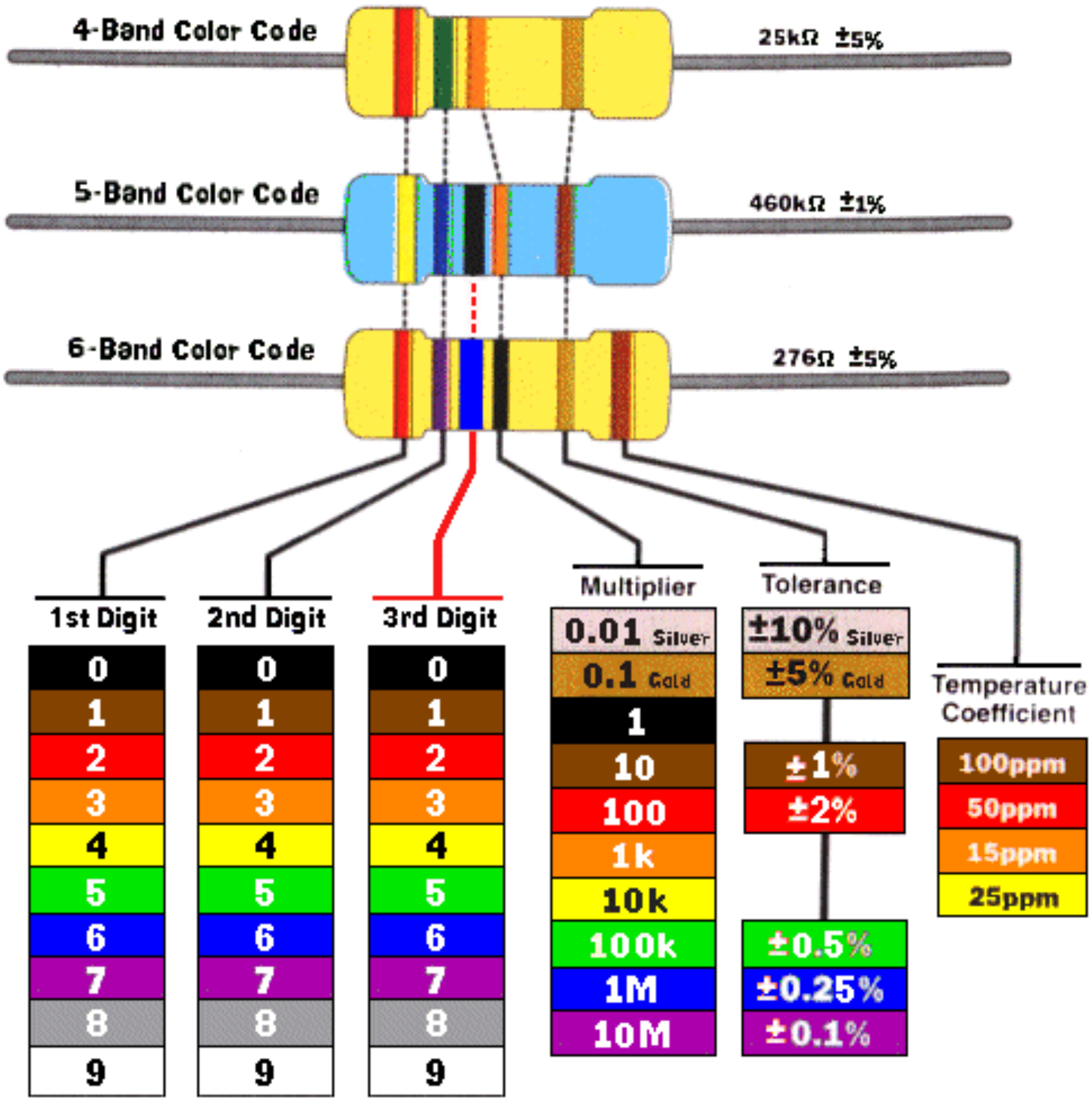
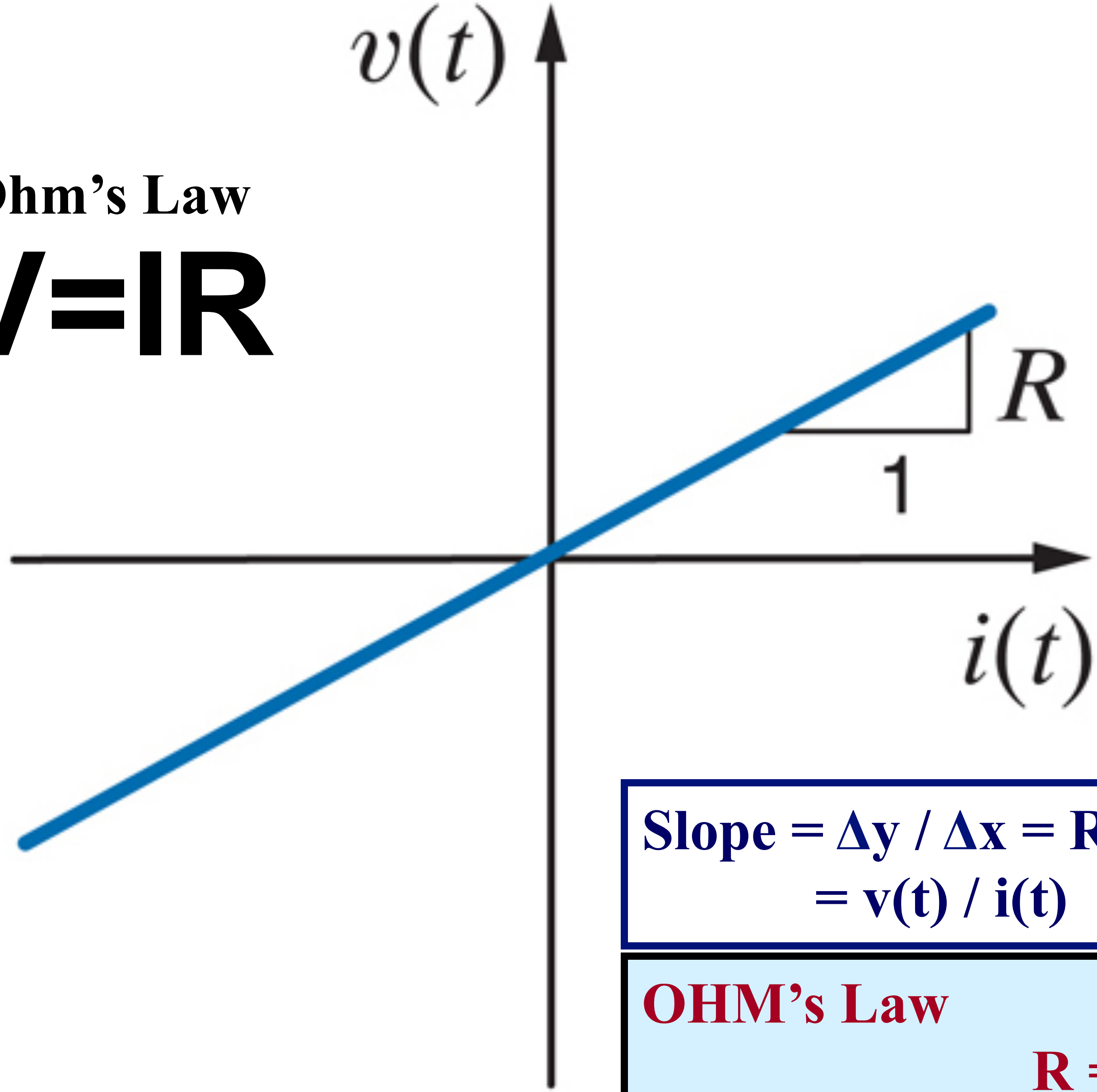

4-Band Color Code
25kΩ ±5%
5-Band Color Code
460kΩ ±1%
6-Band Color Code
276Ω ±5%
1st Digit
0
1
2
3
4
5
6
7
8
9
2nd Digit
0
1
2
3
4
5
6
7
8
9
3rd Digit
0
1
2
3
4
5
6
7
8
9
Multiplier
0.01 Silver
0.1 Gold
1
10
100
1k
10k
100k
1M
10M
Tolerance
±10% Silver
±5% Gold
±1%
±2%
±0.5%
±0.25%
±0.1%
Temperature Coefficient
100ppm
50ppm
15ppm
25ppm

**TABLE 2.1** Standard resistor values for 5% and 10% tolerances (values available with a 10% tolerance shown in boldface)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **1.0** | **10** | **100** | **1.0k** | **10k** | **100k** | **1.0M** | **10M** |
| 1.1 | 11 | 110 | 1.1k | 11k | 110k | **1.1M** | 11M |
| **1.2** | **12** | **120** | **1.2k** | **12k** | **120k** | **1.2M** | **12M** |
| 1.3 | 13 | 130 | 1.3k | 13k | 130k | 1.3M | 13M |
| **1.5** | **15** | **150** | **1.5k** | **15k** | **150k** | **1.5M** | **15M** |
| 1.6 | 16 | 160 | 1.6k | 16k | 160k | 1.6M | 16M |
| **1.8** | **18** | **180** | **1.8k** | **18k** | **180k** | **1.8M** | **18M** |
| 2.0 | 20 | 200 | 2.0k | 20k | 200k | 2.0M | 20M |
| **2.2** | **22** | **220** | **2.2k** | **22k** | **220k** | **2.2M** | **22M** |
| 2.4 | 24 | 240 | 2.4k | 24k | 240k | 2.4M | |
| **2.7** | **27** | **270** | **2.7k** | **27k** | **270k** | **2.7M** | |
| 3.0 | 30 | 300 | 3.0k | 30k | 300k | 3.0M | |
| **3.3** | **33** | **330** | **3.3k** | **33k** | **330k** | **3.3M** | |
| 3.6 | 36 | 360 | 3.6k | 36k | 360k | 3.6M | |
| **3.9** | **39** | **390** | **3.9k** | **39k** | **390k** | **3.9M** | |
| 4.3 | 43 | 430 | 4.3k | 43k | 430k | 4.3M | |
| **4.7** | **47** | **470** | **4.7k** | **47k** | **470k** | **4.7M** | |
| 5.1 | 51 | 510 | 5.1k | 51k | 510k | 5.1M | |
| **5.6** | **56** | **560** | **5.6k** | **56k** | **560k** | **5.6M** | |
| 6.2 | 62 | 620 | 6.2k | 62k | 620k | 6.2M | |
| **6.8** | **68** | **680** | **6.8k** | **68k** | **680k** | **6.8M** | |
| 7.5 | 75 | 750 | 7.5k | 75k | 750k | 7.5M | |
| **8.2** | **82** | **820** | **8.2k** | **82k** | **820k** | **8.2M** | |
| 9.1 | 91 | 910 | 9.1k | 91k | 910k | 9.1M | |

**Ohm's Law**

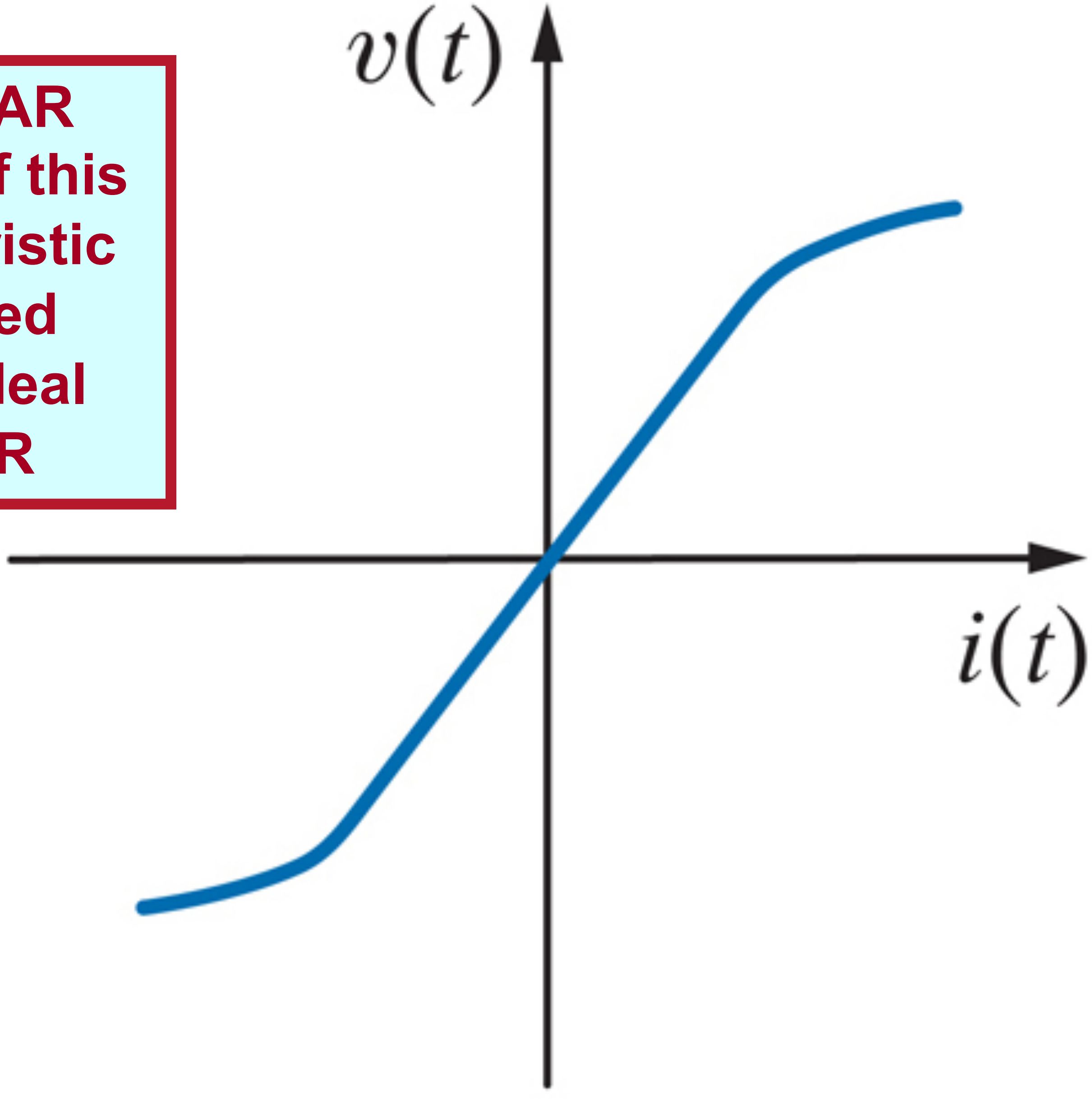
# V=IR




**Slope = Δy / Δx = R**
**= v(t) / i(t)**

**OHM's Law**
**R = v(t) / i(t)**

**The LINEAR portion of this characteristic is modelled with an ideal RESISTOR**

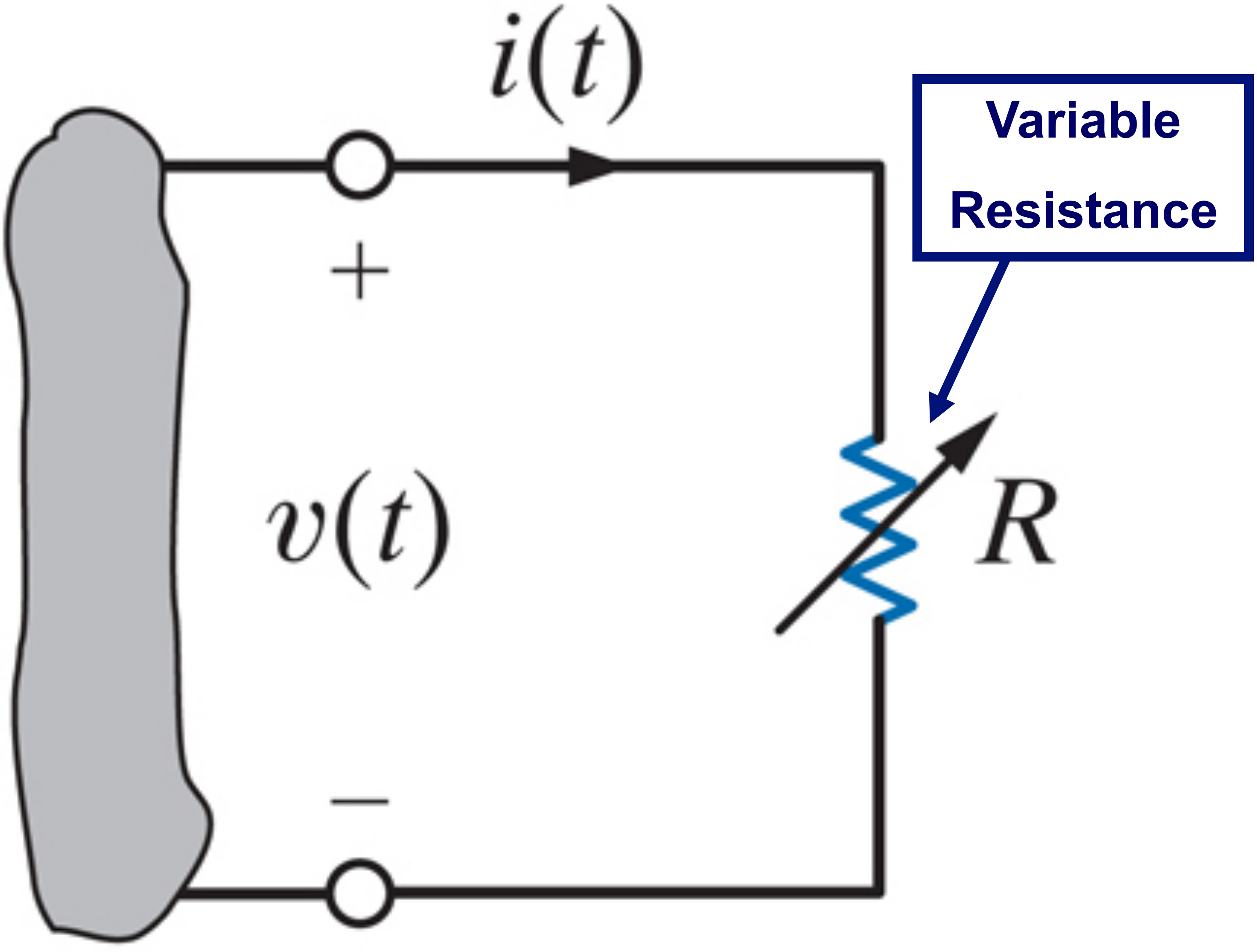


**Georg Simon Ohm** was a German physicist born in Erlangen, Bavaria, on March 16, 1787. As a high school teacher, Ohm started his research with the recently invented electrochemical cell, invented by Italian Count Alessandro Volta. Using equipment of his own creation, Ohm determined that the current that flows through a wire is proportional to its cross sectional area and inversely proportional to its length, or Ohm's law.

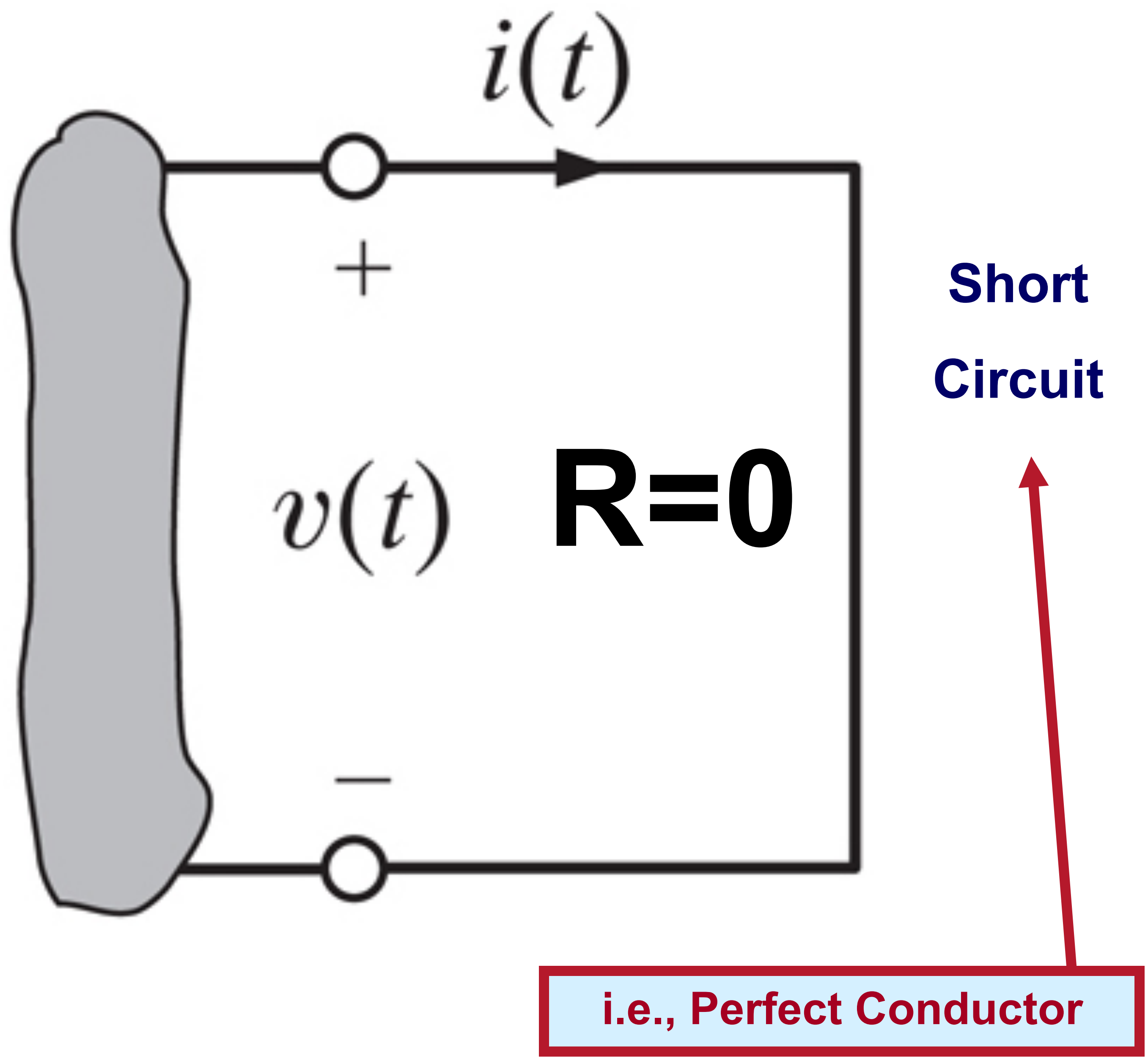
Using the results of his experiments, Georg Simon Ohm was able to define the fundamental relationship between voltage, current, and resistance. These fundamental relationships are of such great importance, that they represent the true beginning of electrical circuit analysis.

Unfortunately, when Ohm published his finding in 1827, his ideas were dismissed by his colleagues. Ohm was forced to resign from his high-school teaching position and he lived in poverty and shame until he accepted a position at Nüremberg in 1833 and although this gave him the title of professor, it was still not the university post for which he had strived all his life.

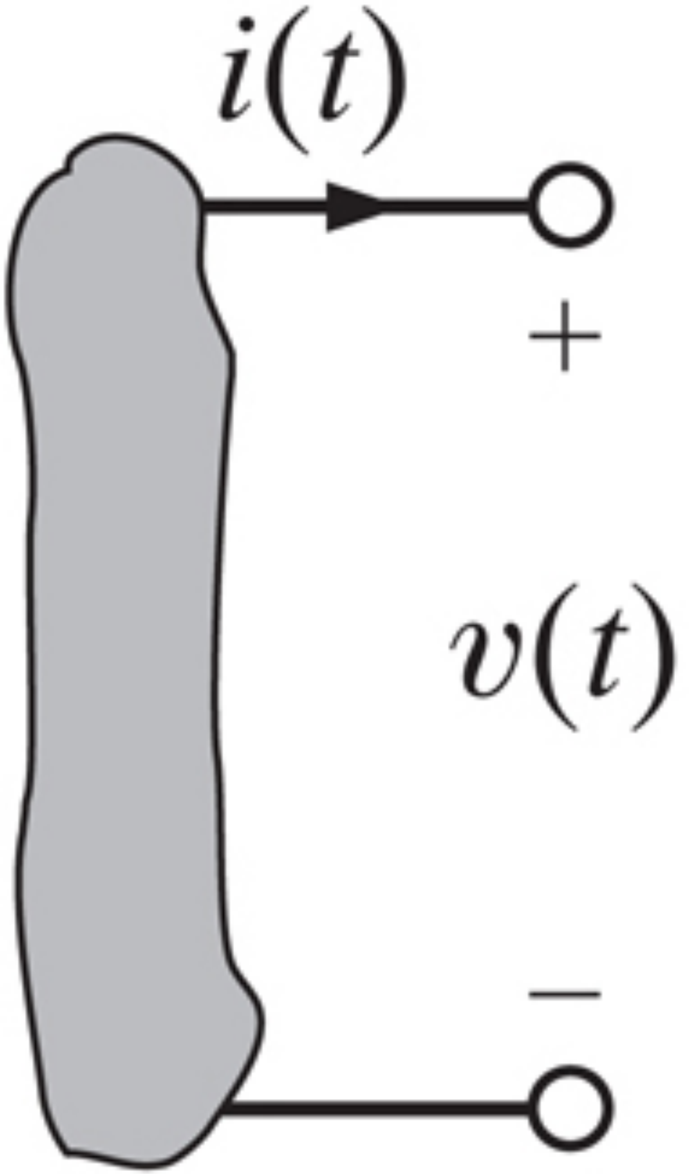
## Georg Simon Ohm
**(1787 – 1854)**



i(t)
Variable
Resistance
+
v(t)
R
−



i(t)
+
v(t)
R=0
−
Short
Circuit
i.e., Perfect Conductor




# R=∞

**Open Circuit**

# Conductance

A measure of the ability of a material to conduct current.

Notation: G

$G = 1/R$

Unit: Siemans (S)

(Used to be Mhos ℧ or $\Omega^{-1}$)

# More Ohm's Law

***Ohm's law:***

$$V = IR$$

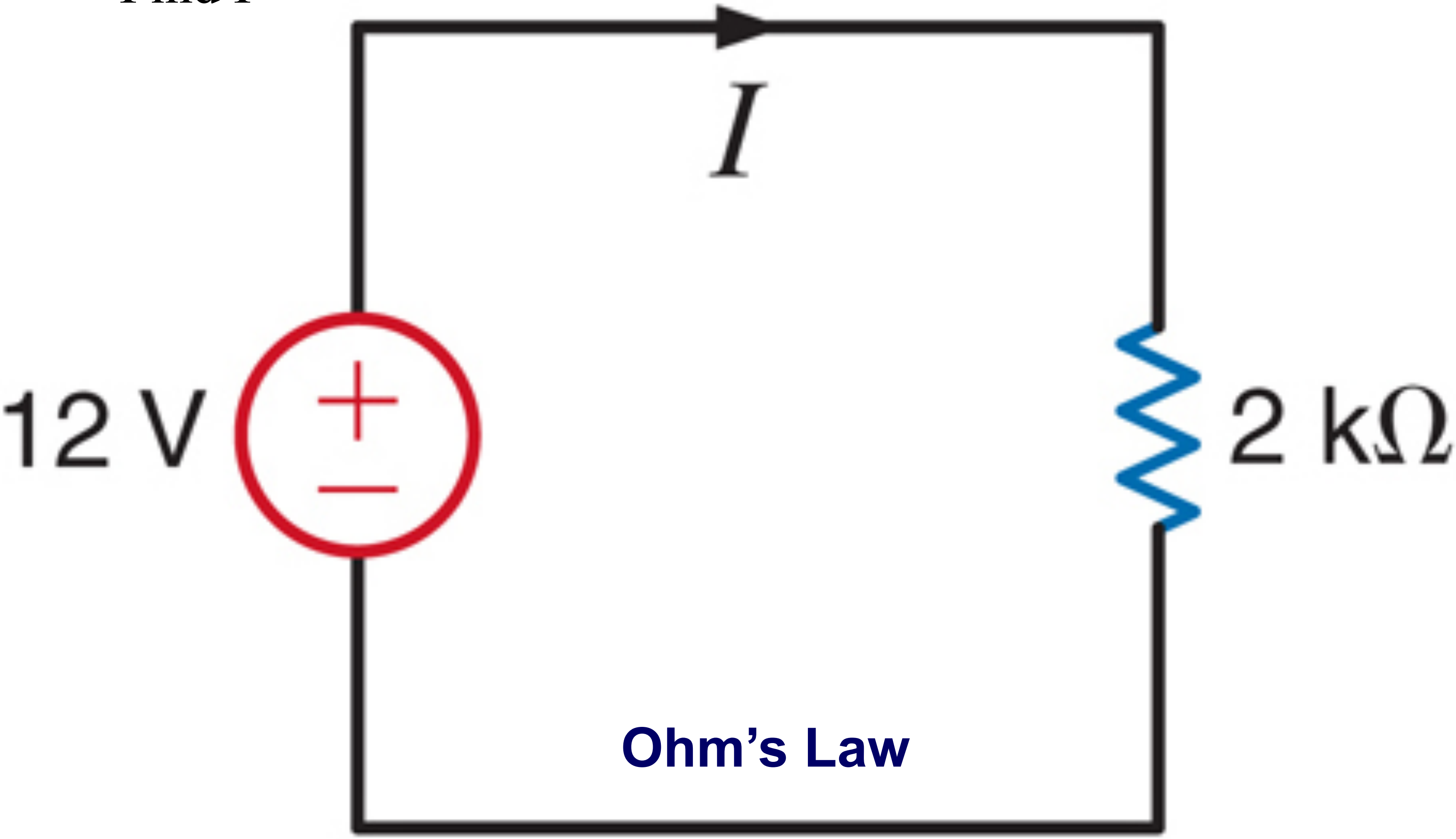
***Power in resistors:***

$$P = VI = RI^2 = \frac{V^2}{R}$$

***Conductance (Siemens):***

$$G = \frac{1}{R}$$

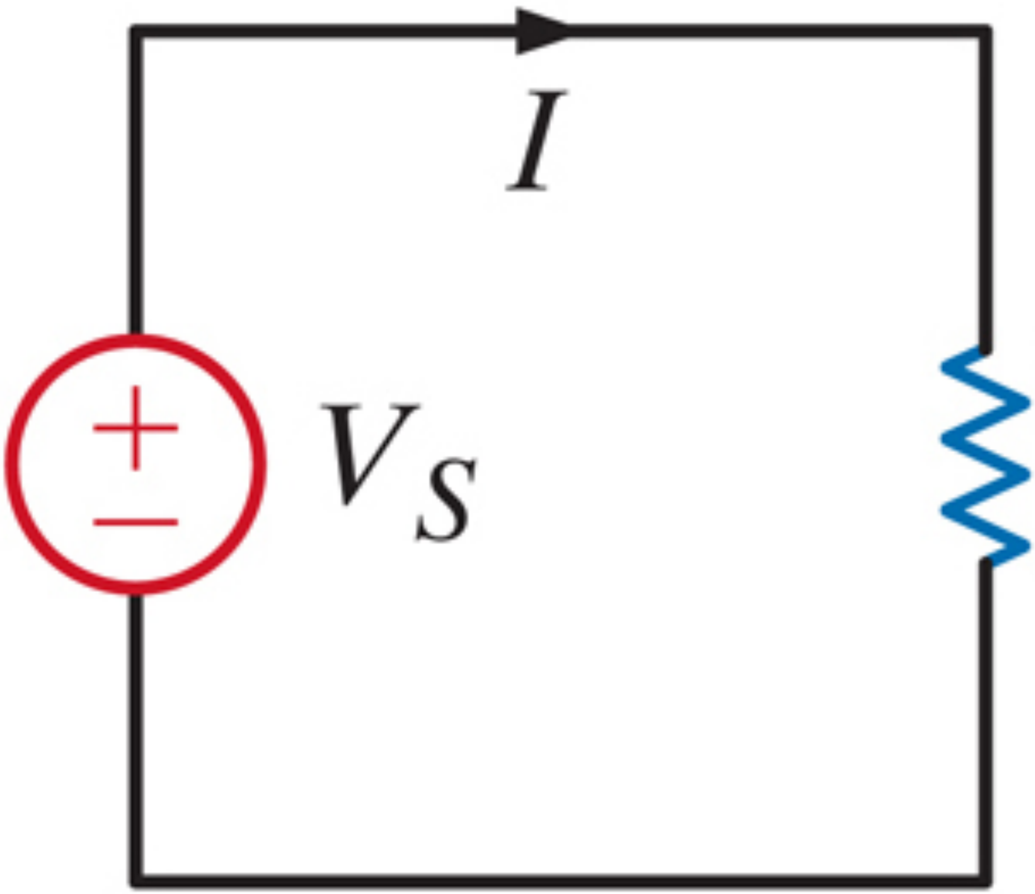
Find I




**Ohm’s Law**

**12 volts = I (2kΩ) or I = 6 mA**

Find $V_S$ and I




$P = V^2 / R$ or

$V^2 = 3.6\ \text{mW} \times 10\ \text{k}\Omega$

$= 36 \times 10^{-0}$

$V = 6$ Volts

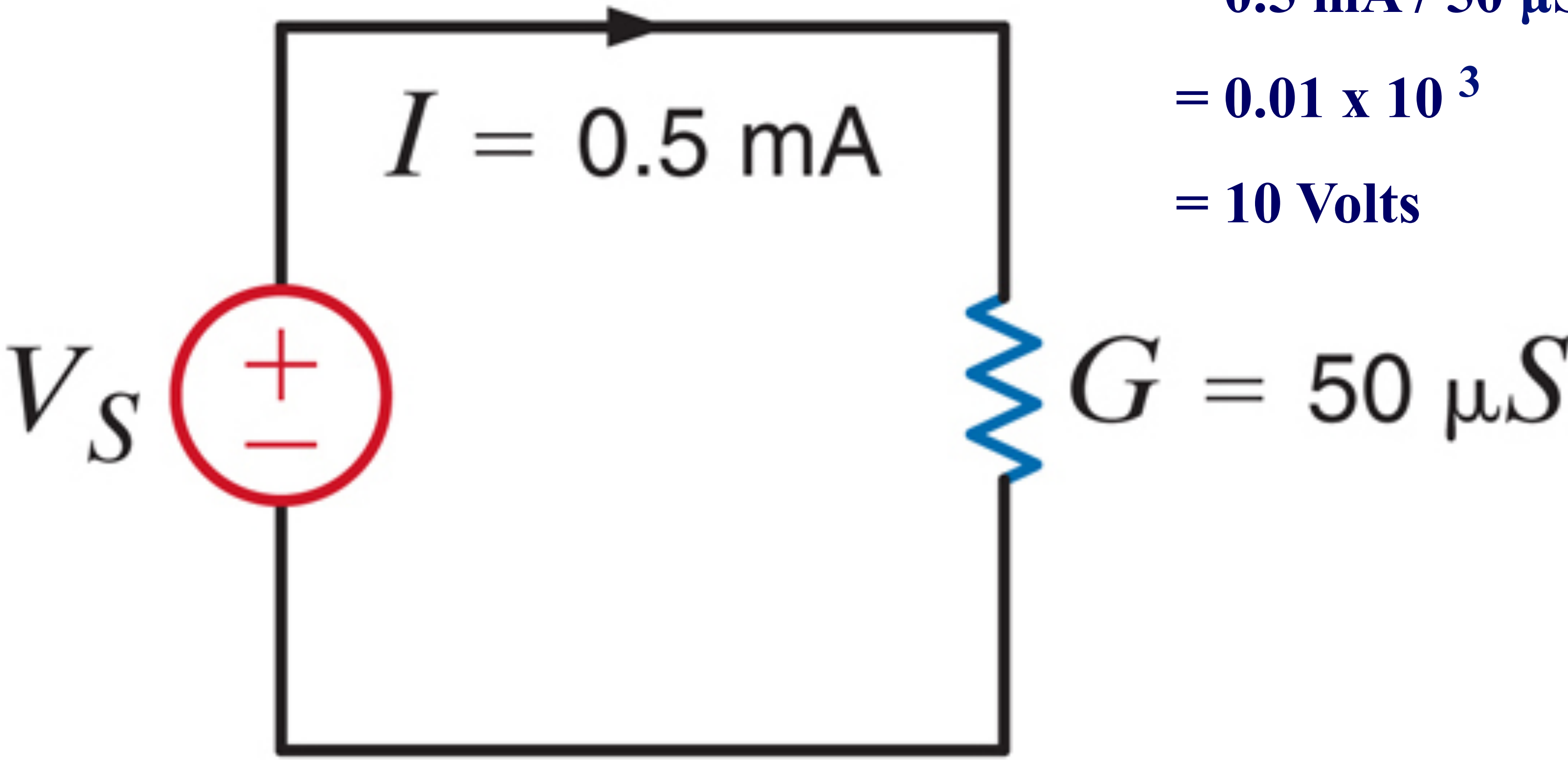
$P = I^2 R$ or

$I^2 = 3.6\ \text{mW} / 10\ \text{k}\Omega$

$= 0.36 \times 10^{-6}$

$I = 0.6$ mA

Find $V_S$




**Ohm's Law**

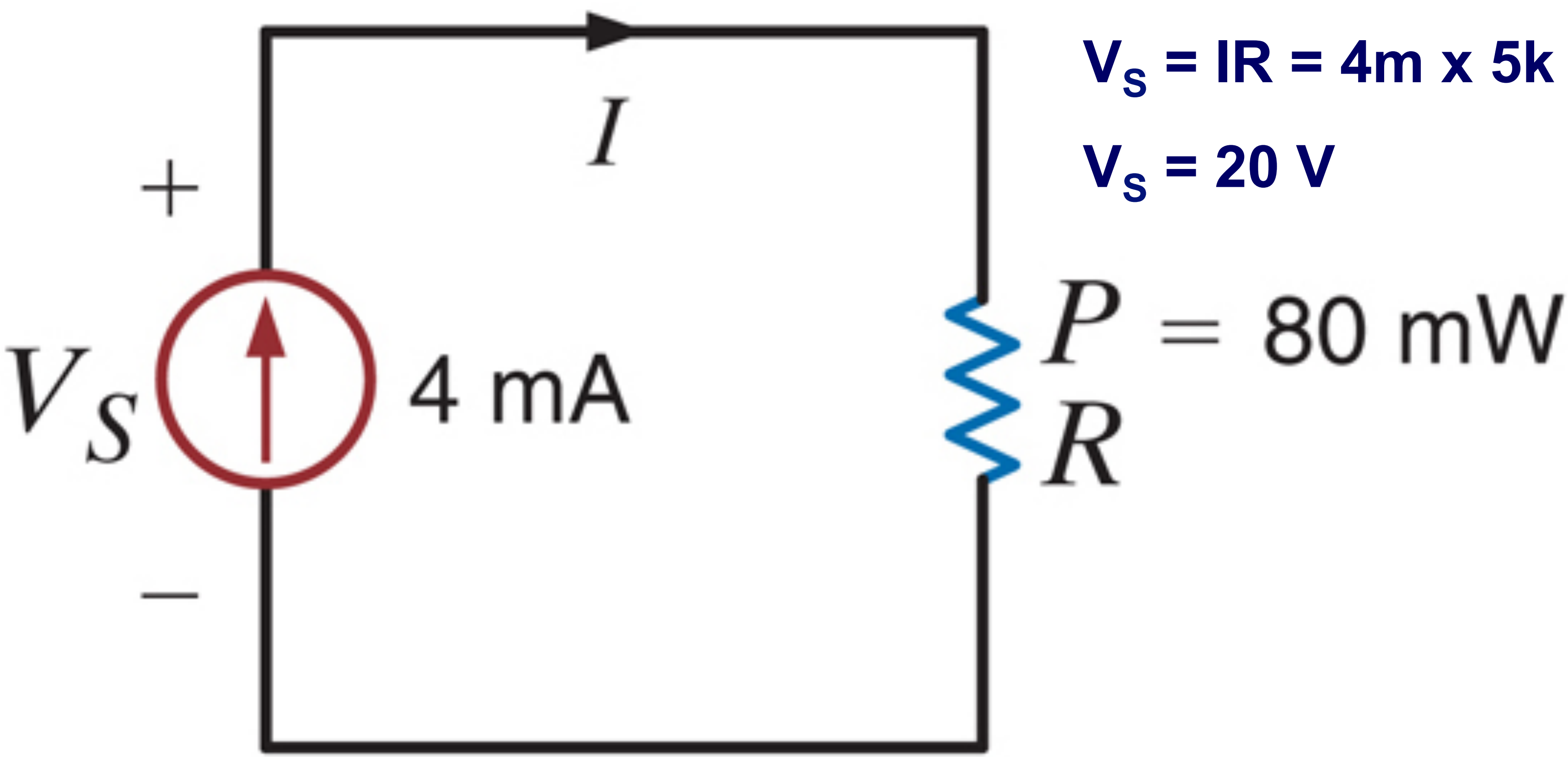
$$V_S = I\,R = I\,/\,G$$

$$= 0.5\text{ mA} / 50\ \mu\text{S}$$

$$= 0.01 \times 10^{3}$$

$$= 10\text{ Volts}$$

Find R and $V_S$




$P = I^2 R$

$= (4mA)^2 R$

$= 80$ mW

$R = 80 \times 10^{-3} / 16 \times 10^{-6}$

$= 5 \times 10^3 = 5\ k\Omega$

$V_S = IR = 4m \times 5k$

$V_S = 20$ V