# Basic Electronics: Ohm's Law and Basic Circuit Components

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Figure: A "theoretical" physics lab

Figure: Applications of Quantum technology: Medical Imaging

# Introduction to Voltage, Current, and Resistance

- **Voltage ($V$)**: Electrical potential difference
- **Current ($I$)**: Flow of electric charge
- **Resistance ($R$)**: Opposition to current flow

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## Ohm's Law

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

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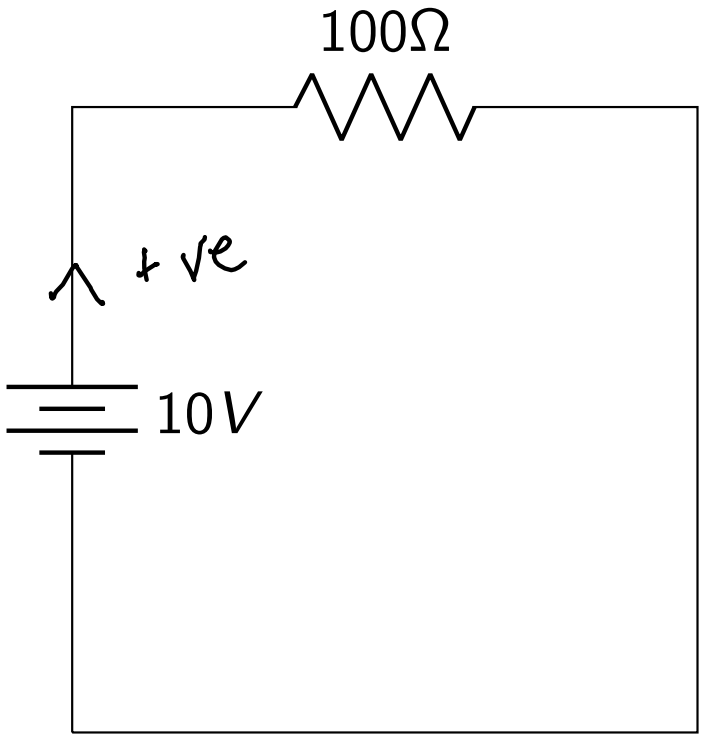
## Ohm's Law

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

## Power Formula

$$P = V \cdot I = I^2 \cdot R = \frac{V^2}{R}$$

# Ohm's Law: Example Circuit




what is the current?

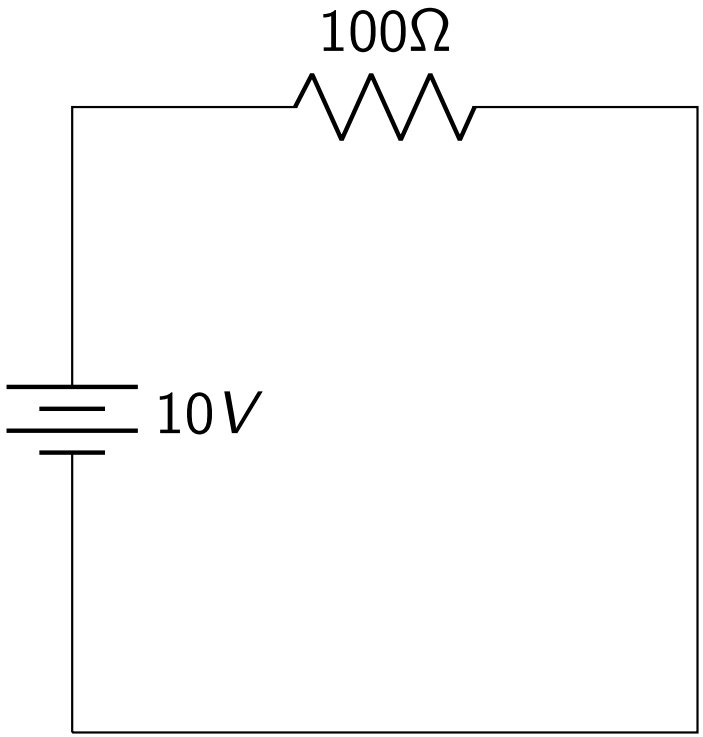
$V = IR$

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

$= \frac{10}{100} = 0.1A.$

Calculate the current

# Ohm's Law: Example Circuit




## Calculate the current

Using Ohm's Law:

$$I = \frac{10V}{100\Omega} = 0.1A$$

# Power Dissipation in Resistors

Example: Power in a 100Ω Resistor with 10V Supply

$$P = I^2 R = IV = \frac{V^2}{R}$$

$$= \frac{10\,0\,V^2}{100\,\Omega} = 1\ \text{Watt}.$$

# Power Dissipation in Resistors

Example: Power in a 100Ω Resistor with 10V Supply

$$P = \frac{10^2}{100} = 1W$$

# Sample Question for Audience

## Question

A resistor of $R = 50\,\Omega$ is connected to a 20V battery. What is the current flowing through the resistor?

$$V = IR$$

$$I = \frac{V}{R} = \frac{20}{50} = 0.4\,A$$

# Sample Question for Audience

## Question

A resistor of $R = 50\,\Omega$ is connected to a 20V battery. What is the current flowing through the resistor?

## Answer

$$I = \frac{V}{R} = \frac{20}{50} = 0.4A$$

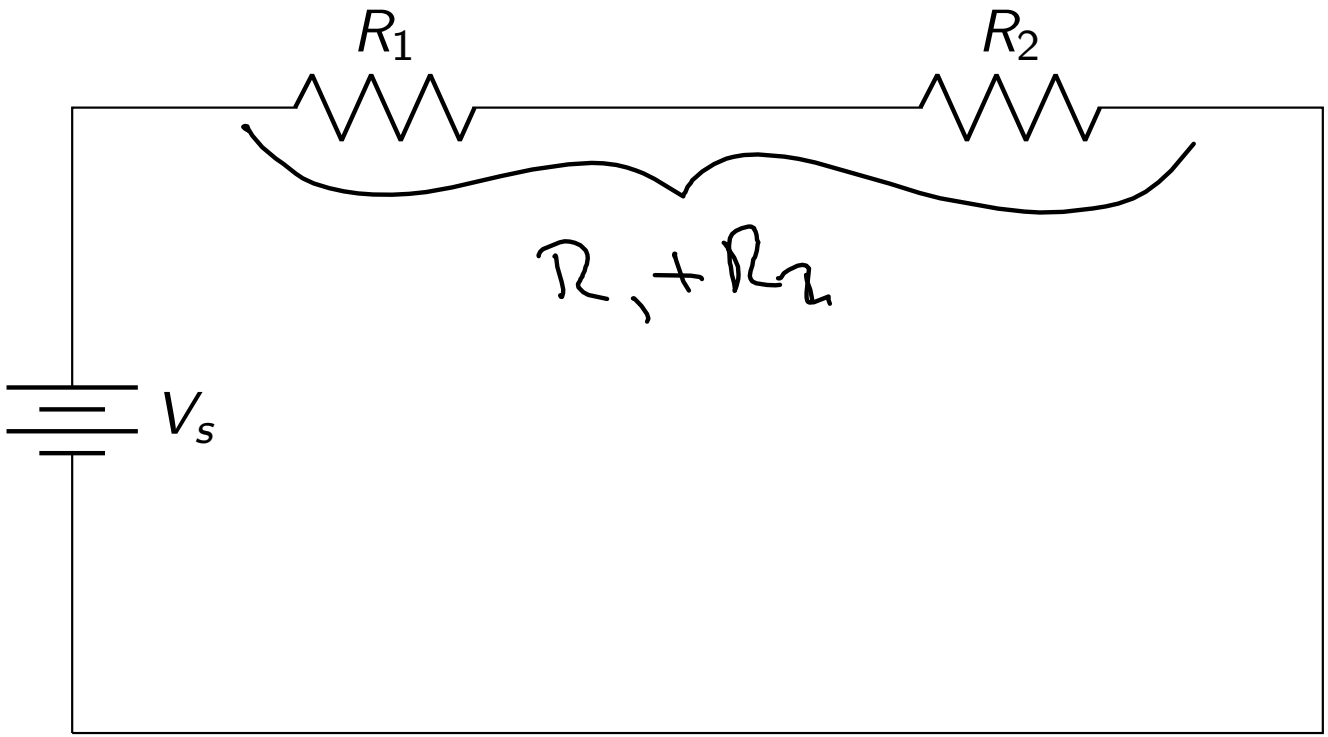
# Summary of Ohm's Law

- Relationship between voltage, current, and resistance.
- Power dissipation in resistors.
- Applications in simple DC circuits.

# Resistors in Series

## Total Resistance in Series

$$R_{\text{total}} = R_1 + R_2 + \cdots + R_n$$



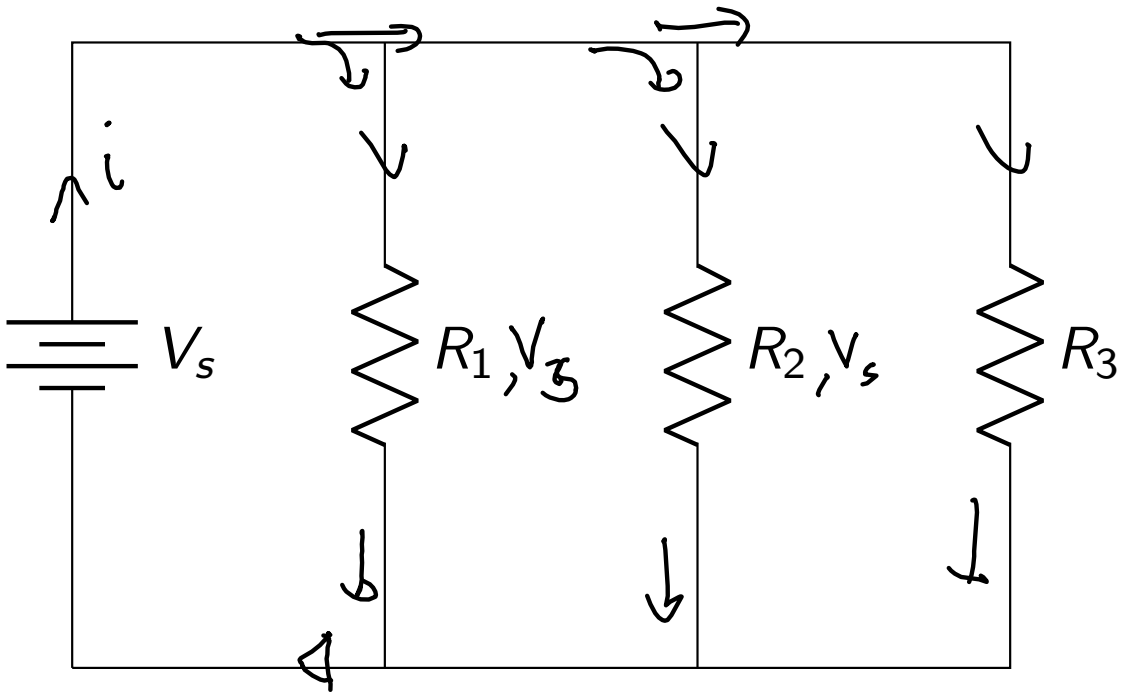
# Resistors in Parallel

$V = IR$

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

## Total Resistance in Parallel

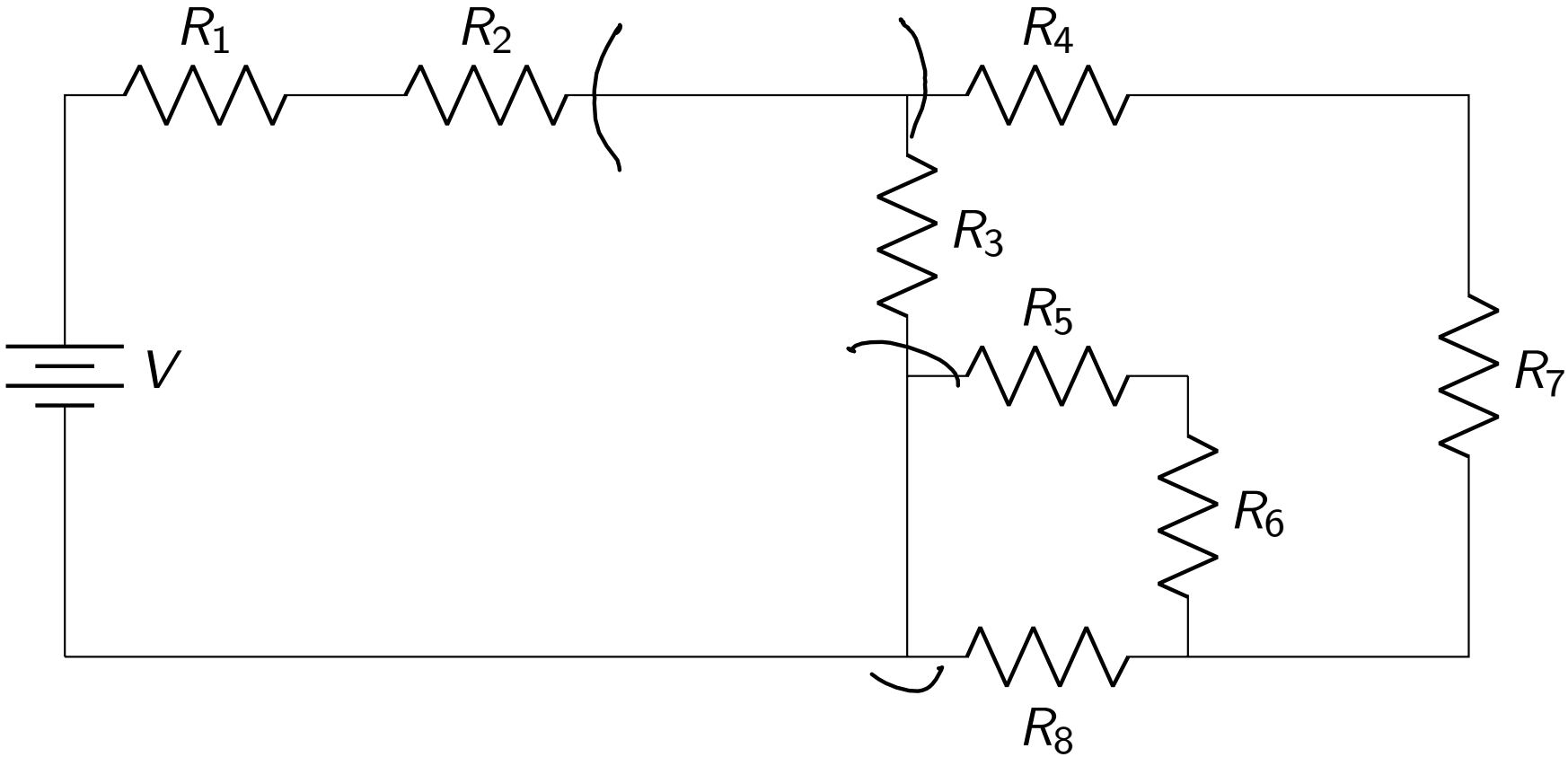
$$\frac{1}{R_{\text{total}}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}$$




$I_T = I_1 + I_2 + \ldots I_N$

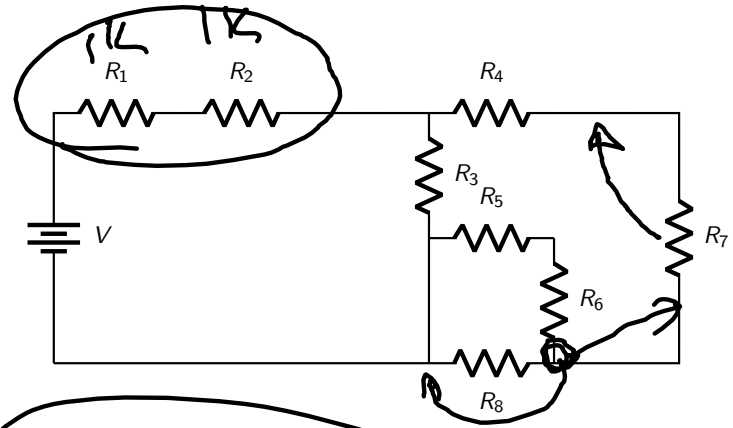
$\frac{1}{R_T} = \frac{1}{R_1} + \ldots$

# Series and Parallel Combination Example

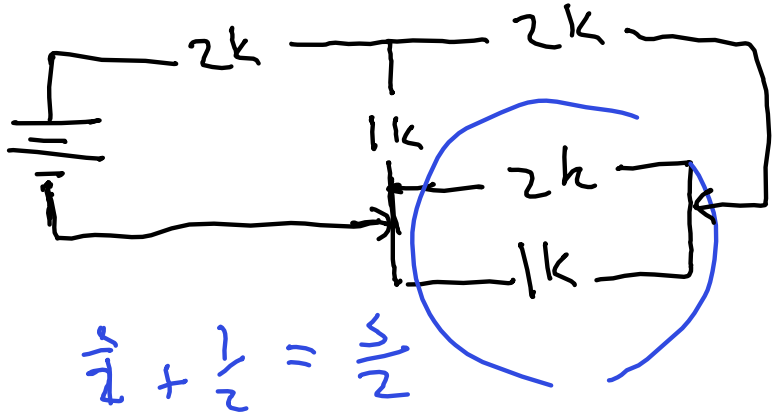



Calculate the Total Resistance (All $R = 1k\Omega$)

# Circuit Simplification

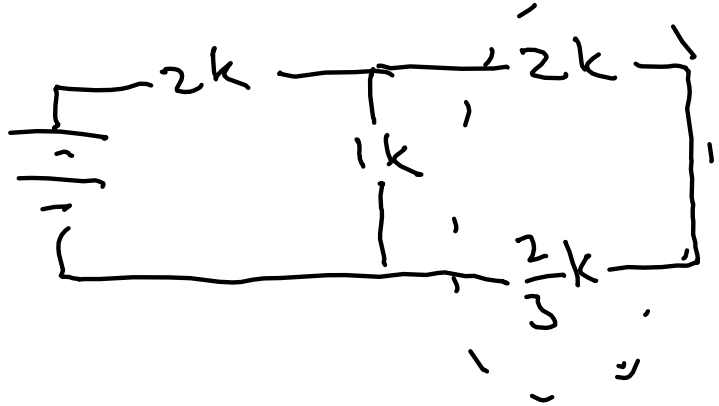




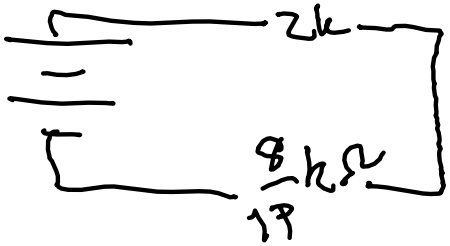




$\frac{3}{2} + \frac{1}{2} = \frac{5}{2}$

$\frac{1}{R} = \frac{1}{1k} + \frac{1}{2.66k}$

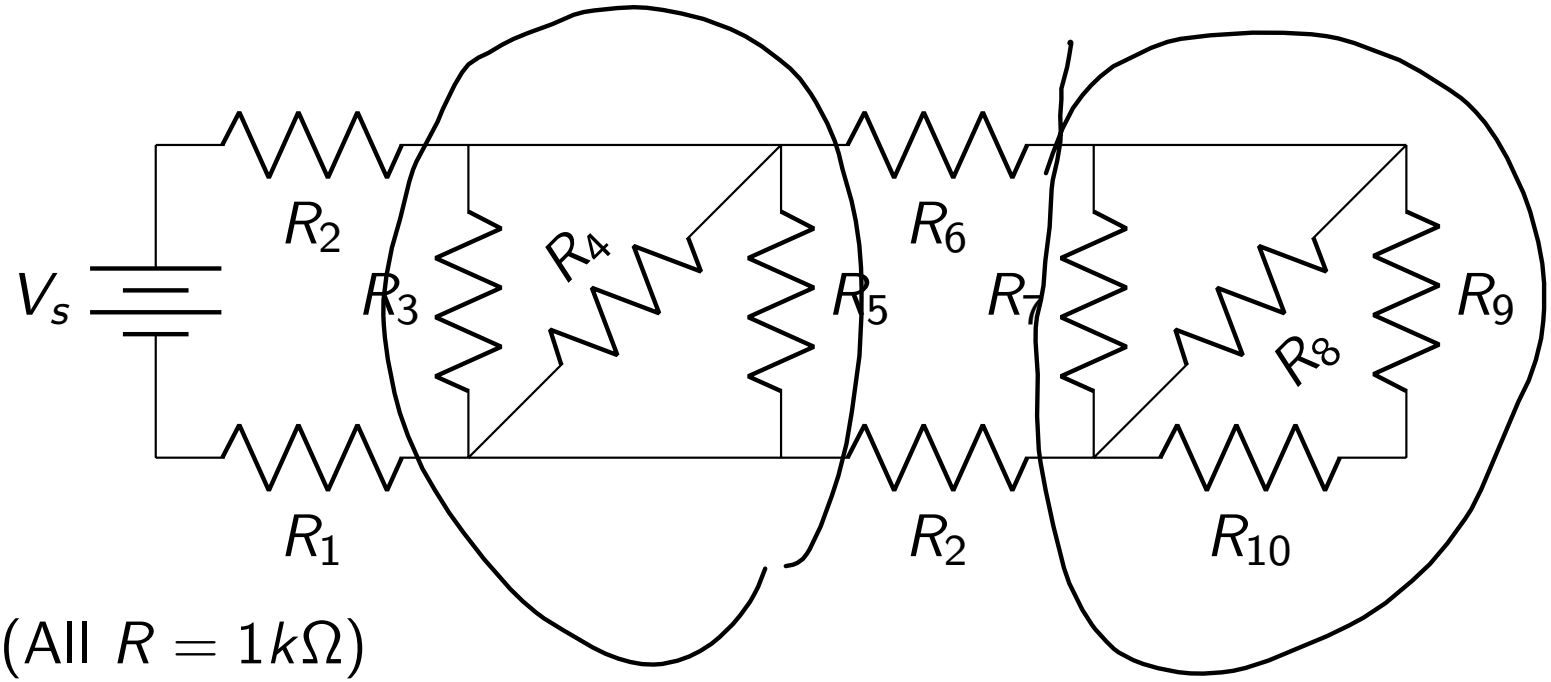



$R = \frac{8}{11}\Omega$



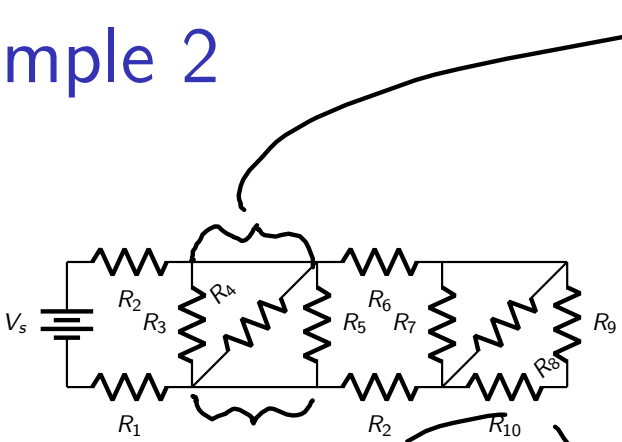

$\frac{30}{11}k\Omega$

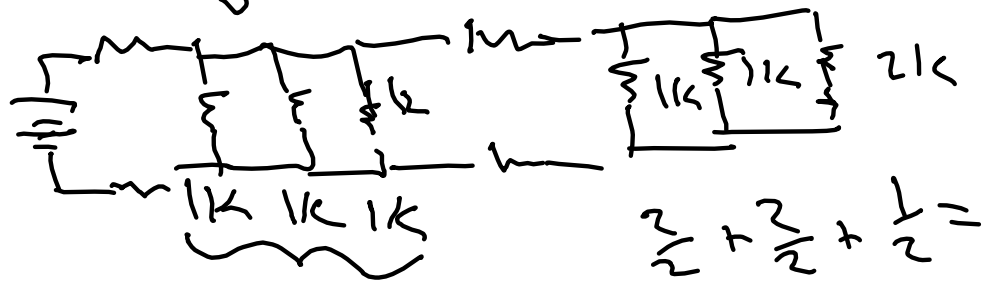
# Example 2

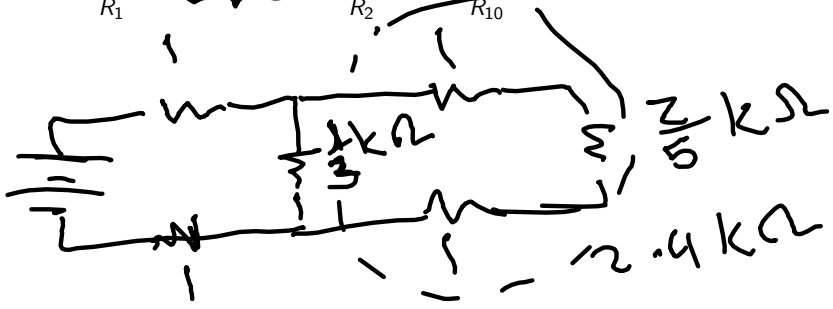


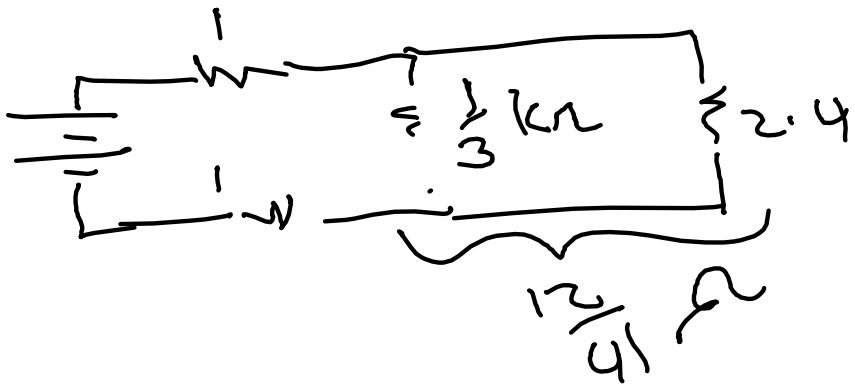

(All $R = 1k\Omega$)

# Example 2



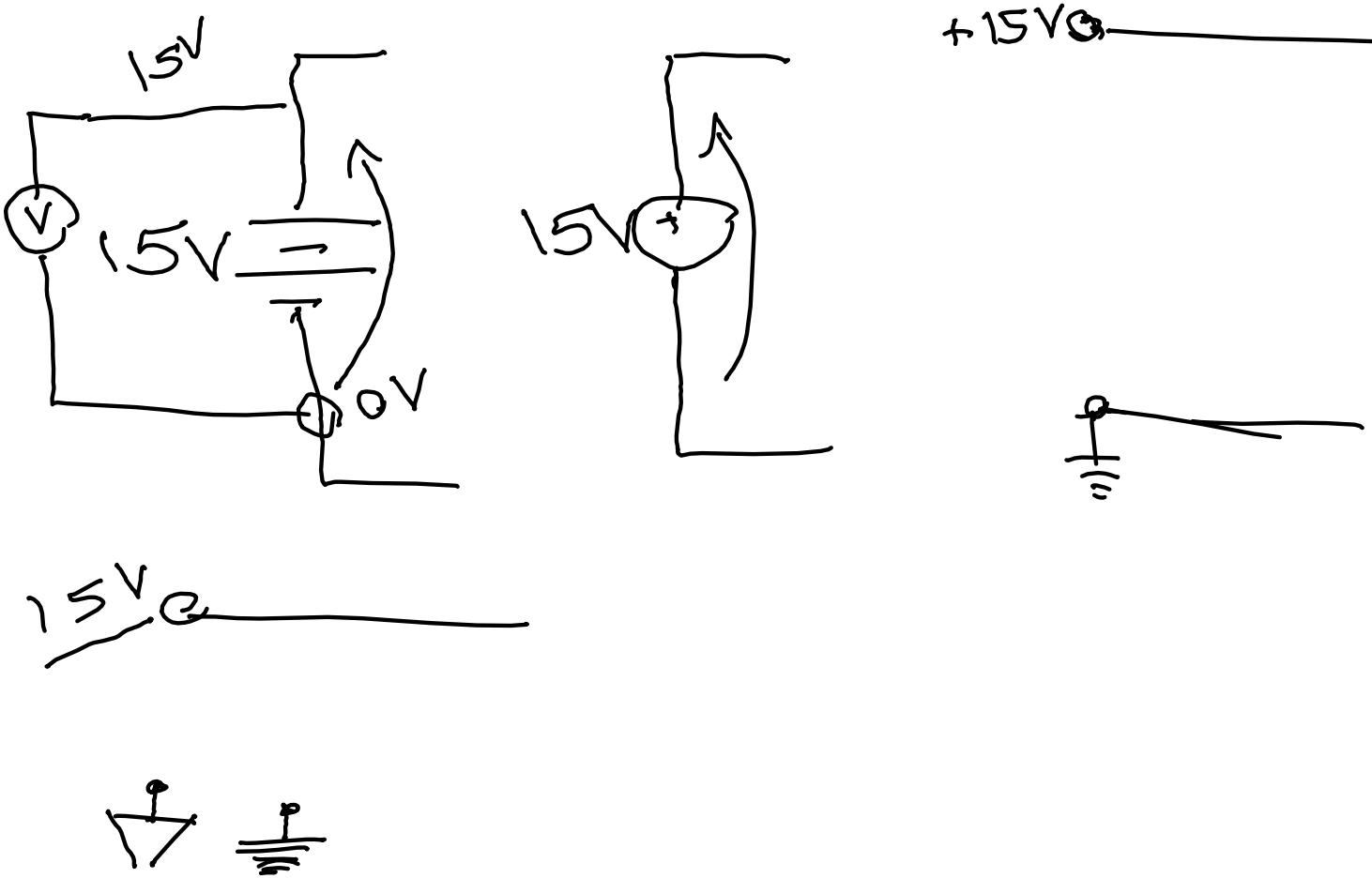

$2\,k\Omega + \frac{12}{41}k\Omega = \frac{94}{41}\,k\Omega.$

# Summary of Series and Parallel Resistors

- Total resistance in series: Additive.
- Total resistance in parallel: Reciprocal of sum of reciprocals.
- Applications in network analysis.

# Practical Example: Voltage Divider Circuit

We have a 15V power supply but we need a 5V power supply...



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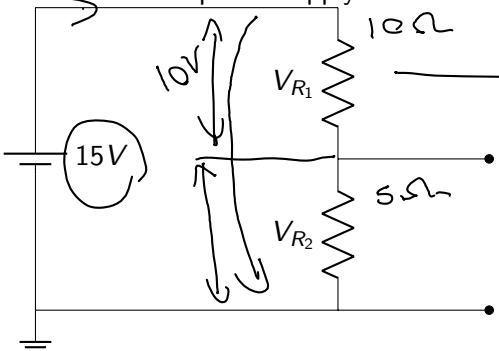


$5V = IR_2$

$10V = IR_1$

$R_2 = \frac{5V}{I}$

$= \frac{5V}{10V} R_1$

$\frac{R_2}{R_1} = \frac{5}{10}$

$\frac{R_2}{R_1} = \frac{1}{2}$

$2R_2 = R_1$

# Practical Example: Voltage Divider Circuit

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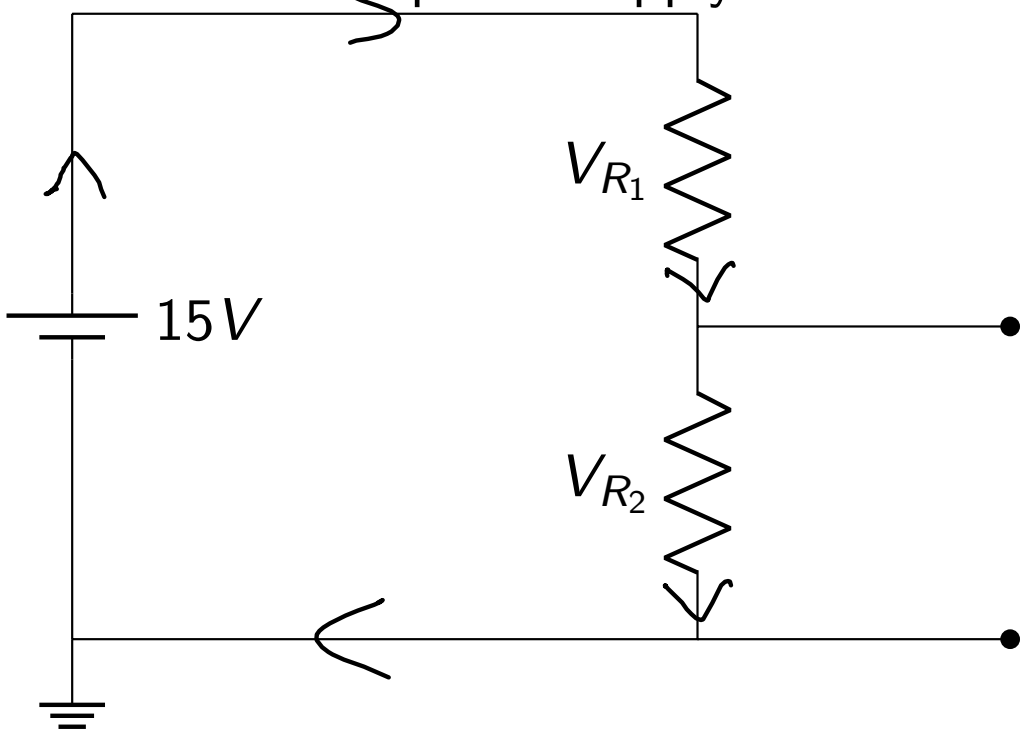



## Question

what resistances do we choose to have 5V across $R_2$?

# Solving the Voltage Divider Circuit

## Step 1: Calculate Total Resistance

$$R_{\text{total}} = R_1 + R_2 = 10\Omega + 20\Omega = 30\Omega$$

## Step 2: Calculate Current

$$I = \frac{V_s}{R_{\text{total}}} = \frac{12V}{30\Omega} = 0.4A$$

# Final Step: Voltage Across $R_2$

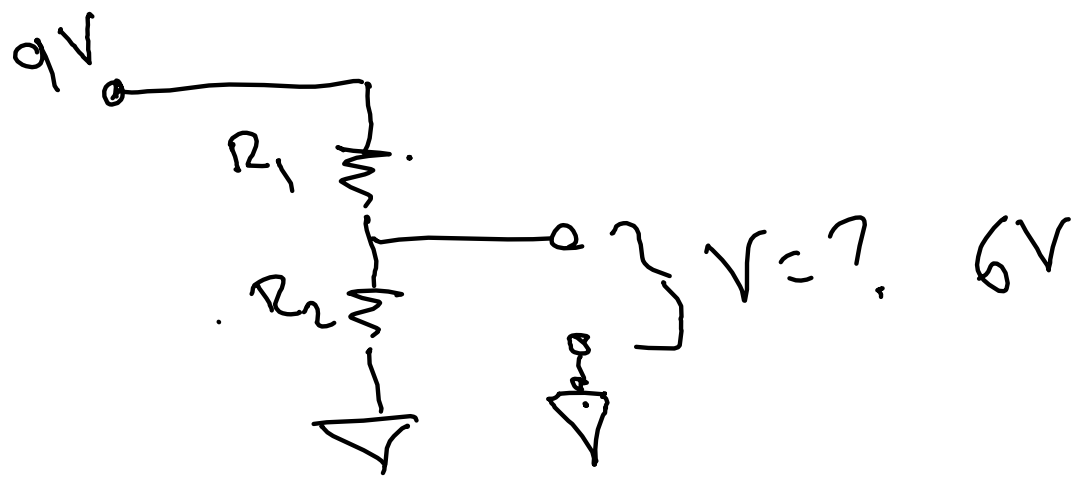
## Calculate Voltage Drop Across $R_2$

$$V_{R_2} = I \cdot R_2 = 0.4A \times 20\Omega = 8V$$

# Sample Problem

## Question

In a voltage divider with $V_s = 9V$, $R_1 = 15\Omega$, and $R_2 = 30\Omega$, calculate the voltage across $R_2$.




$V = IR$

$R = 45\Omega$

$\frac{9}{45} = I$

$IR_2 = V_{R2}$

# Sample Problem

## Question

In a voltage divider with $V_s = 9V$, $R_1 = 15\Omega$, and $R_2 = 30\Omega$, calculate the voltage across $R_2$.

## Answer

$$V_{R_2} = \frac{9V}{15\Omega + 30\Omega} \times 30\Omega = 6V$$

# Summary of Practical Applications

- Voltage divider circuits are common in electronics.
- Ohm's Law can be used to solve for unknown voltages, currents, and resistances.