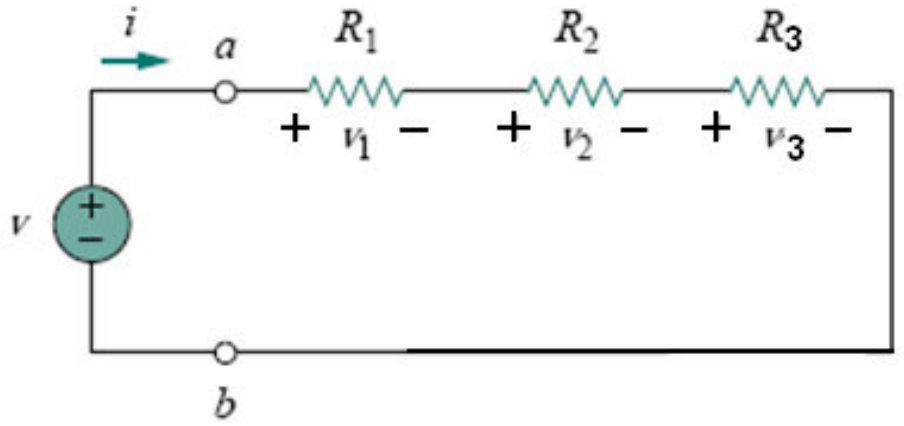
Voltage and Current Division Rules

Objectives

- To apply the voltage and current division rules.

Voltage Division



For example, we know

$i = V_{TOTAL} / (R_1 + R_2 + R_3)$

so the voltage over the **first resistor** is

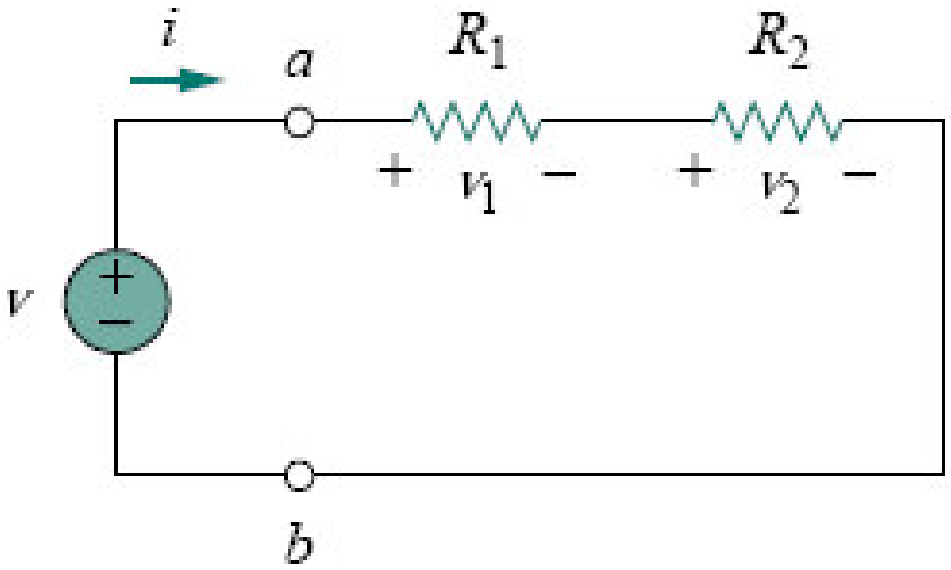
$V_1 = i R_1 = R_1 V_{TOTAL} / (R_1 + R_2 + R_3)$

$$v_1 = V \frac{R_1}{R_1 + R_2 + R_3}$$

To find the voltage over an individual resistance in series, take the total series voltage and multiply by the individual resistance over the total resistance.

Example

determine the voltage across each resistor



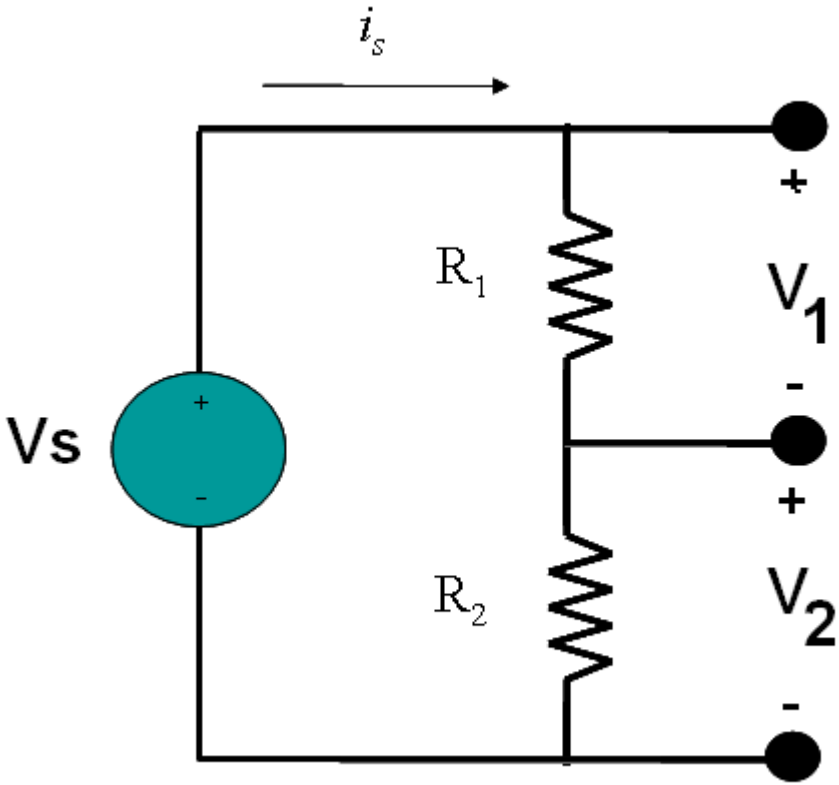
$$v_1 = \frac{R_1}{R_1 + R_2} v \qquad v_2 = \frac{R_2}{R_1 + R_2} v$$

Example
determine the voltage acros
each resistor

$$i_s = \frac{v_s}{R_1 + R_2}$$

$$v_1 = \frac{R_1}{R_1 + R_2} v_s$$

$$v_2 = \frac{R_2}{R_1 + R_2} v_s$$



Summary

•The source voltage *v* is divided among the resistors in direct proportion to their resistances

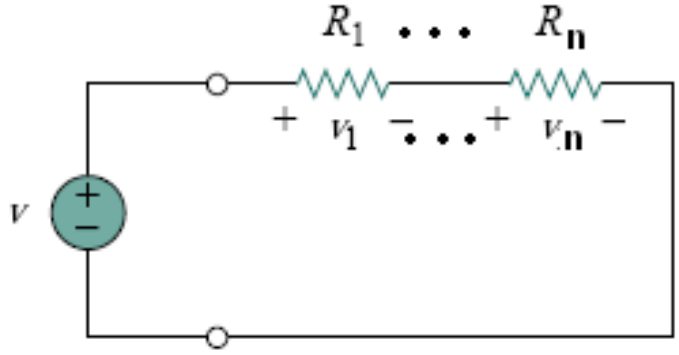
•the larger the resistance, the larger the voltage drop.

•This is called the *principle of voltage division*,

•In general

If a voltage divider has *N* resistors ($R_1, R_2, \ldots, R_N$) in series with the source voltage *v*, the n^{th} resistor (R_n) will have a voltage drop of

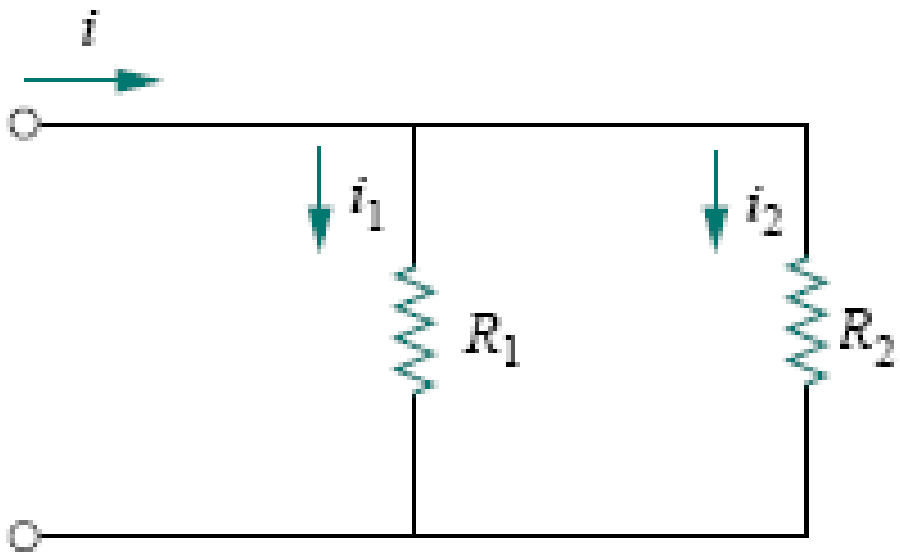
$$v_n = \frac{R_n}{R_1 + R_2 + \cdots + R_N} v$$



Current Division

If we know the current flowing into **two parallel resistors,** we can find out how the current will divide up in one step.

$$v = i\frac{R_1 R_2}{R_1 + R_2} \leftarrow R_{Eq}$$

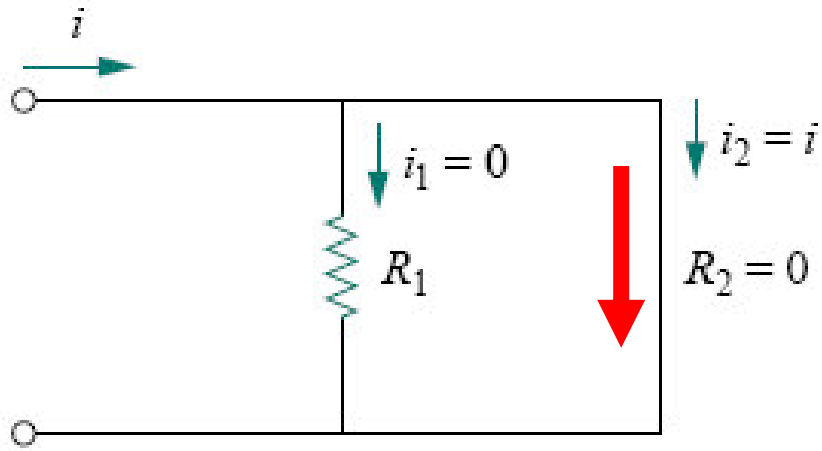


$$i_1 = \frac{v}{R_1}$$

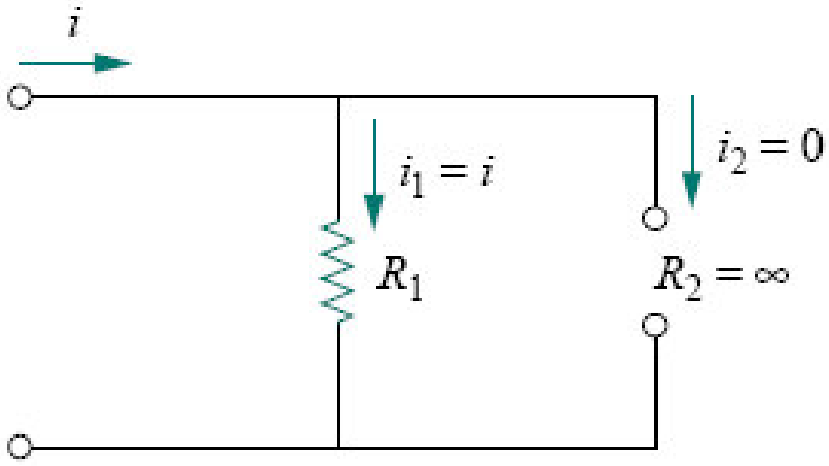
$$i_1 = \frac{1}{R_1}\left[i\frac{R_1 R_2}{R_1 + R_2} \right] \Rightarrow \boxed{i_1 = i\frac{R_2}{R_1 + R_2}}$$

$$i_1 = \frac{R_2\, i}{R_1 + R_2} \qquad i_2 = \frac{R_1\, i}{R_1 + R_2}$$

Note that this differs slightly from the voltage division formula for series resistors



$R_2 = 0$ implies that $i_1 = 0$, $i_2 = i$.

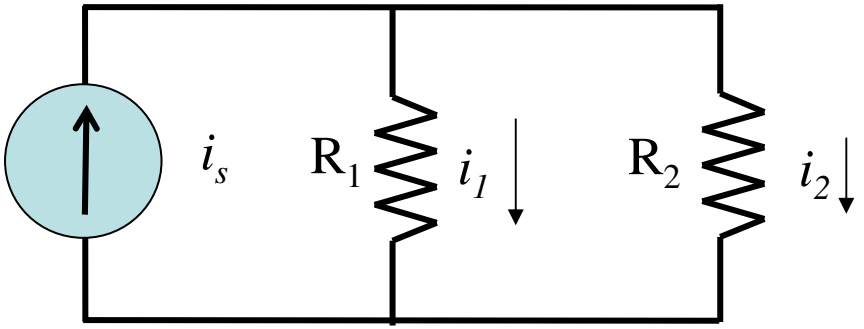


$R_2 = \infty$, that is, R_2 is an open

$R_2 \rightarrow \infty$, then
$R_{eq} = R_1$

Example

Find i_1 and i_2 in terms of i_s



$$i_s = i_1 + i_2$$

$v_1 = v_2$

$$i_1 R_1 = i_2 R_2$$

$$i_2 = i_1 \frac{R_1}{R_2} \Rightarrow i_s = i_1 + i_1 \frac{R_1}{R_2} = i_1 \left(\frac{R_2 + R_1}{R_2} \right)$$

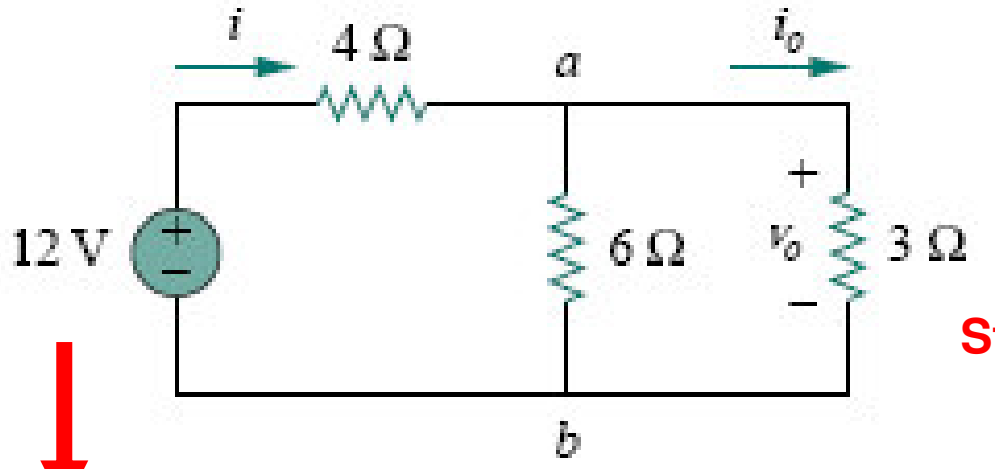
$$i_1 = i_s \left(\frac{R_2}{R_1 + R_2} \right)$$

$$i_2 = i_s \left(\frac{R_1}{R_1 + R_2} \right)$$

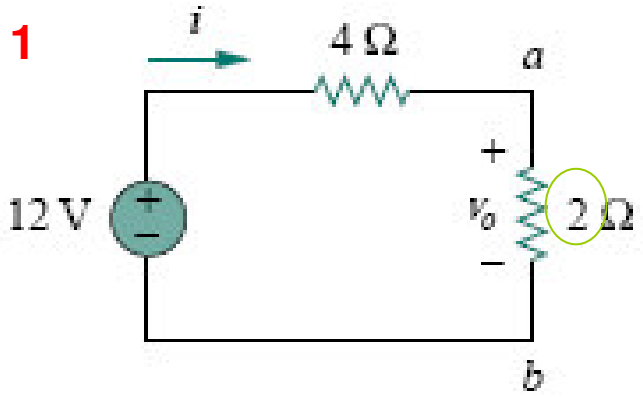
Example

Use Voltage and current division rules to find V_o and i_o

$$\frac{6 \cdot 3}{6+3} = 2$$



Step 1



Step 2

Step 1

$$i = \frac{12}{4+2} = 2\ \text{A}$$

$$v_o = \frac{2}{2+4}(12\ \text{V}) = 4\ \text{V}$$

$$i_o = \frac{6}{6+3} i = \frac{2}{3}(2\ \text{A}) = \frac{4}{3}\ \text{A}$$