Electronics
Kirchhoff's Laws

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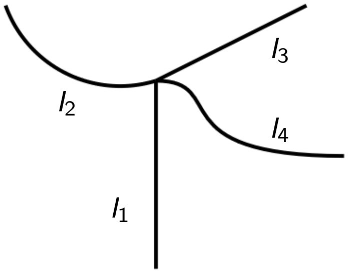
Kirchhoff's Current Law



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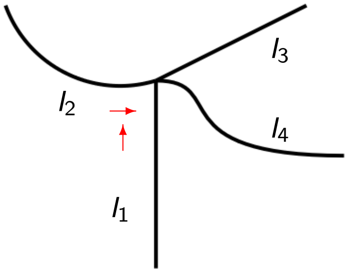

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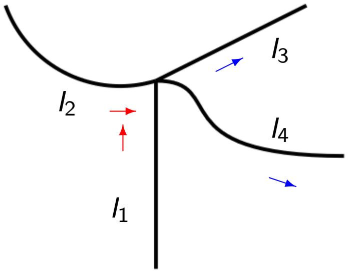

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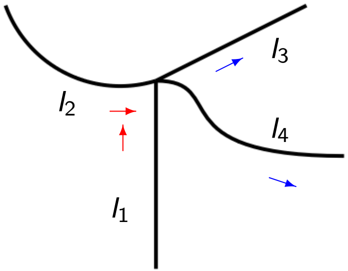

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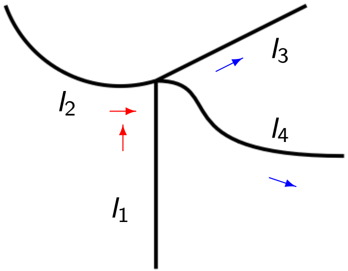
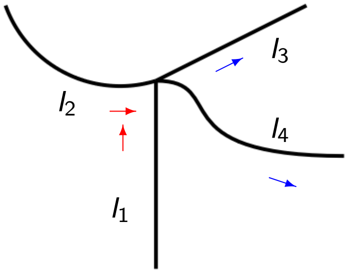


Sum of the currents at a node is zero

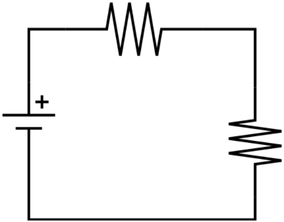
Kirchhoff's Current Law



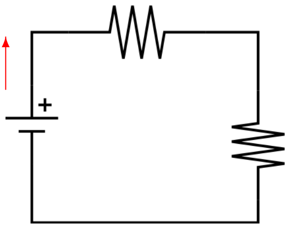
Sum of the currents at a node is zero

$\rightarrow$ Sum of the currents *into* a node equals the sum of the currents *out of* the node.

Kirchhoff's Voltage Law



Kirchhoff's Voltage Law



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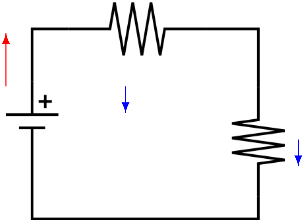
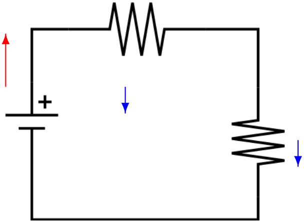
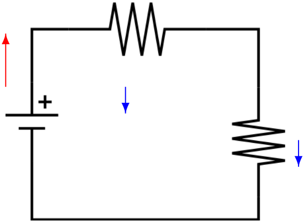


Kirchhoff's Voltage Law



Sum of the voltage drops around a loop is zero

Kirchhoff's Voltage Law



Sum of the voltage drops around a loop is zero

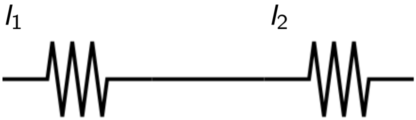
→ Sum of the voltage *increases* in a loop equals the sum of the voltage *drops* in the loop

Applications of Kirchhoff's Current Law

Applications of Kirchhoff's Current Law

Series Circuits

Series Circuits



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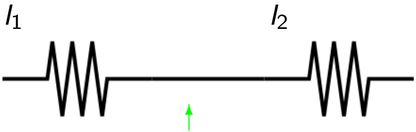
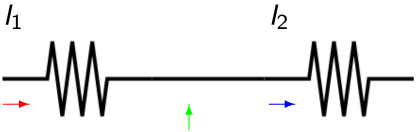


A "virtual" node can be created between the two resistors

Series Circuits

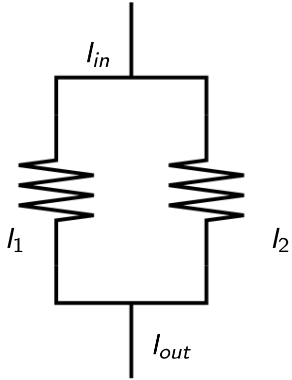


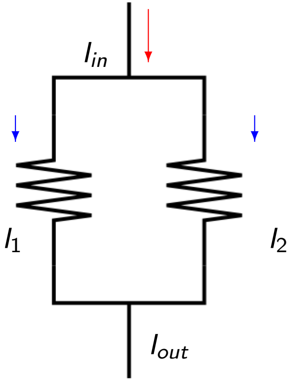
Since there is nowhere else for current to go, $I_1 \equiv I_2$

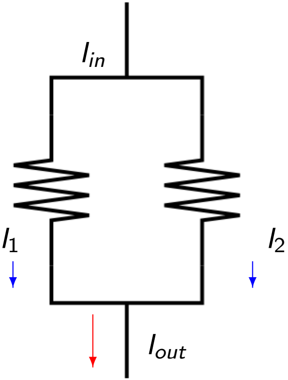
Applications of Kirchhoff's Current Law

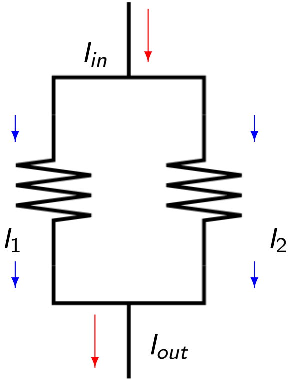
Applications of Kirchhoff's Current Law

Parallel Circuits

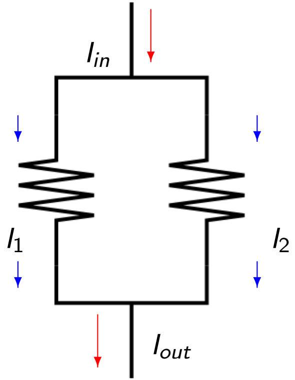

I_{in}
I_1
I_2
I_{out}


I_{in}
I_1
I_2
I_{out}


I_{in}
I_1
I_2
I_{out}



The current exiting at the bottom has to equal the current entering at the top

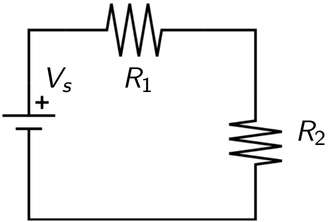


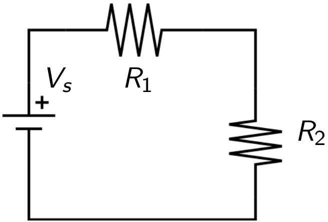
$$I_{in} = I_1 + I_2 = I_{out}$$

Applications of Kirchhoff's Voltage Law

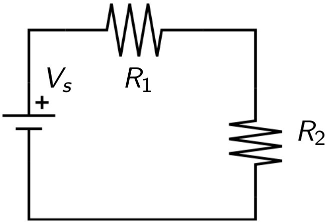
Applications of Kirchhoff's Voltage Law

Voltage dividers

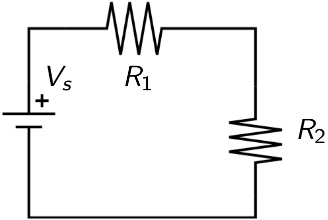

V_s
+
R_1
R_2



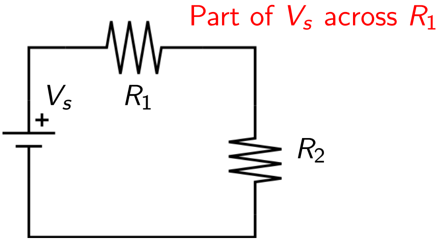
$$V_s = V_{R_1} + V_{R_2}$$



- A **voltage divider** "divides" the supply voltage



- A **voltage divider** "divides" the supply voltage
- It's useful when you need a different voltage than the supply



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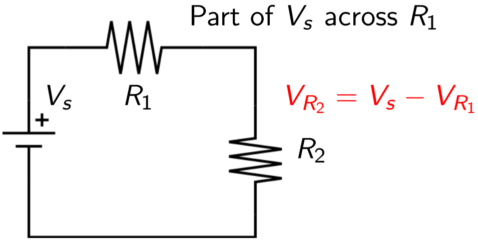

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Since the current is the same in both resistors, the voltage is *divided* between the two; thus it is a **voltage divider**.

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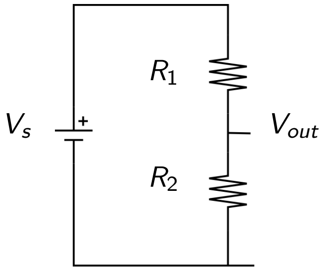
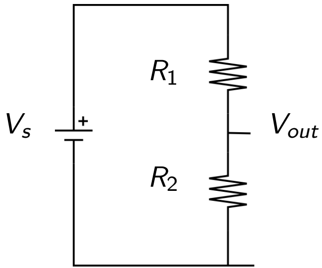
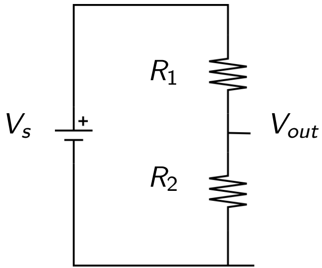

R_1
V_s
+
V_{out}
R_2

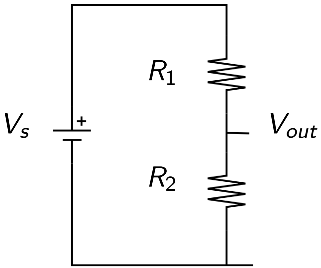


Usually a voltage divider is drawn like this so it looks like a ladder.

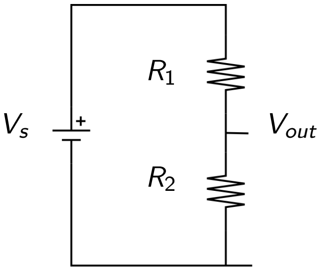


Usually a voltage divider is drawn like this so it looks like a ladder.

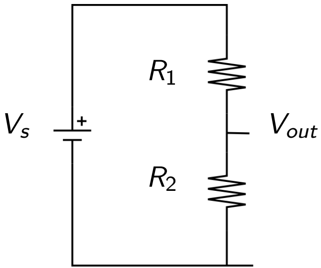
As you climb the ladder, the voltage increases.



Since $I_1 = I_2$,

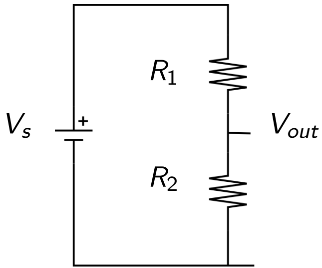


Since $I_1 = I_2$, (by Kirchhoff's current law,)



Since $I_1 = I_2$, (by Kirchhoff's current law),

and $V_s = V_{R_1} + V_{R_2}$,



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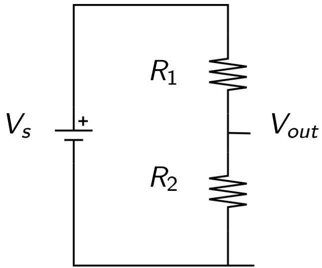

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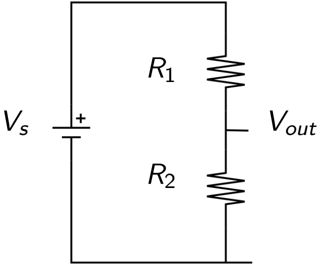
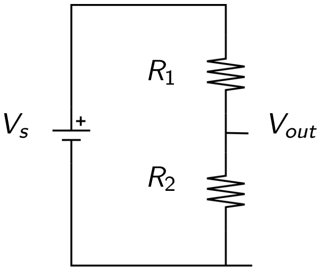
so $V_s = I_1 R_1 + I_1 R_2$



Since $I_1 = I_2$, (by Kirchhoff's current law),

and $V_s = V_{R_1} + V_{R_2}$,(by Kirchhoff's voltage law),

so $V_s = I_1 R_1 + I_1 R_2 = I\,(R_1 + R_2)$



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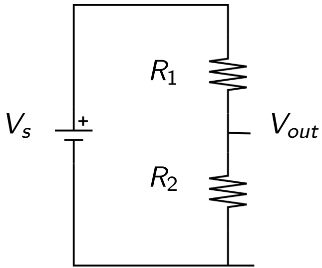
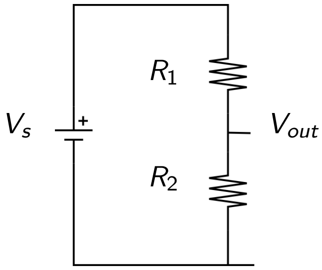
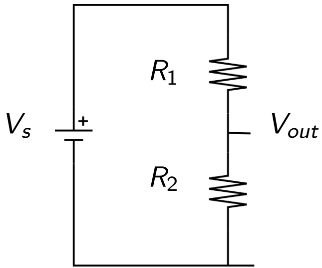
$I = \frac{V_s}{R_1 + R_2}$



So $V_{out} = V_2 = IR_2$



So $V_{out} = V_2 = IR_2 = \frac{V_s}{R_1+R_2}R_2$



So $V_{out} = V_2 = IR_2 = \frac{V_s}{R_1+R_2} R_2$

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

Voltage divider (no load)

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V_{out}

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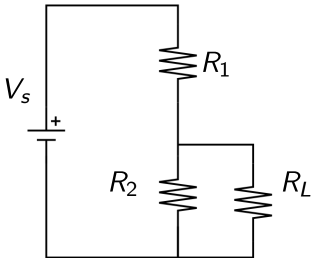
$$V_{out} = V_s\left(\frac{R_2}{R_1+R_2}\right) = 5\left(\frac{10}{5+10}\right)$$

Voltage divider (no load)

If $R_1 = 5\Omega$, $R_2 = 10\Omega$, $V_s = 5V$

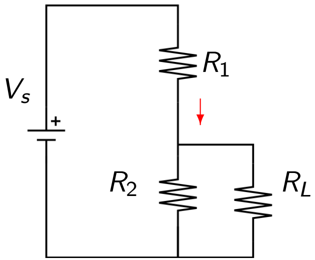
$$V_{out}$$
$$= V_s\left(\frac{R_2}{R_1+R_2}\right) = 5\left(\frac{10}{5+10}\right)$$
$$= 3.3V$$

Voltage divider (with load RL)



Load will reduce the output voltage

Voltage divider (with load RL)



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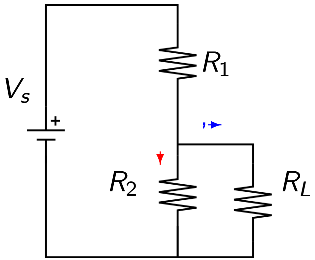

Some current goes through R_2, but some goes through R_L so the *effective* value of R_2 is reduced.

If $R_1 = 5\Omega$, $R_2 = 10\Omega$, $V_s = 5V$ and $R_L = 10\Omega$

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$= \frac{10 \times 10}{10 + 10} = 5\Omega$

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Thus V_{out}

$= V_s \frac{R_p}{R_1+R_p} = 5\left(\frac{5}{5+5}\right)$

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Thus V_{out}

$= V_s \frac{R_p}{R_1+R_p} = 5\left(\frac{5}{5+5}\right)$

$= 2.5V$