Mon: HW

Ex 95, 96, 97, 98

100, 101, 102, 104

Circuit Analysis

The following rules are the foundation for analyzing circuits:

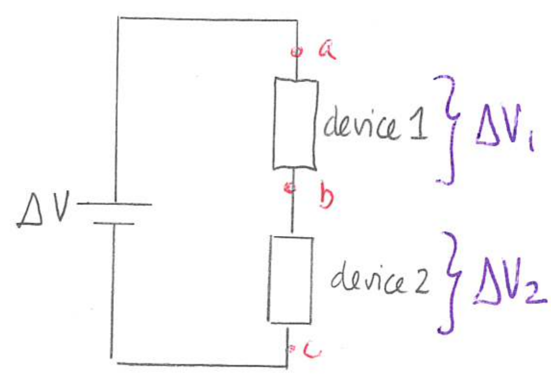
1) in any section of a circuit that is uninterrupted by a junction, the current is the same.

2) at any junction, the current entering equals the current leaving,

3) the potential differences around any closed loop add to zero

Series circuits

In a simple series circuit there are no junctions and devices are connected as illustrated.



Warm Up!

The current rules give:

> The current is the same through all devices connected in series.

For voltages Kirchoff's loop rule gives:

$$\Delta V + \Delta V_{a\to b} + \Delta V_{b\to c} = 0 \quad \Rightarrow \quad \Delta V = -\Delta V_{a\to b} - \Delta V_{b\to c}$$

Note that $\Delta V_{a\to b} = V_b - V_a < 0$. Then $-\Delta V_{a\text{-}b} = V_a - V_b$

For device 1 we can call $V_a - V_b = \Delta V_1 > 0$. Similarly for device 2.

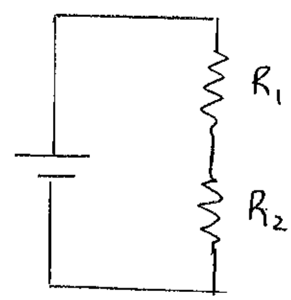
We get

$$\Delta V = \Delta V_1 + \Delta V_2$$

Thus we find

> For devices connected in series, the potential difference (voltage) across the pair of devices splits.

Now suppose that the two devices are resistors. Then Ohm's law applies to each device. So



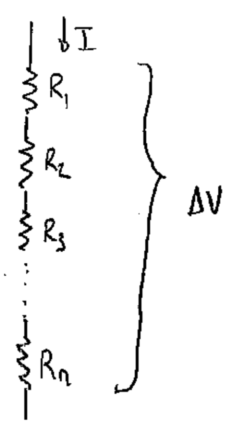
$$\left.\begin{array}{l}\Delta V_1 = I R_1 \\ \Delta V_2 = I R_2\end{array}\right\} \quad \Delta V_i = I R_i$$

We can use this to find the current

$$\Delta V_1 + \Delta V_2 = \Delta V$$
$$IR_1 + IR_2 = \Delta V$$
$$I(R_1 + R_2) = \Delta V.$$

In general:

> Consider a combination of resistors in series. Let ΔV be the potential difference across the entire combination. Let I be the current through the " " .
>
> Then
>
> $$\Delta V = I R_{eq}$$
>
> where the equivalent resistance is
>
> $$R_{eq} = R_1 + R_2 + \dots + R_n$$



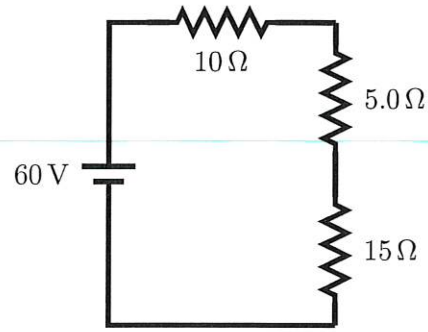
105 Three resistors in series

Three resistors are connected in the illustrated circuit. *(132S22)*

a) Determine the current in the circuit.

b) Determine the potential difference across each resistor.

c) Determine the power delivered to each resistor.



Answers a) $\Delta V = I R_{eq}$

$R_{eq} = R_1 + R_2 + R_3 = 10\,\Omega + 5\,\Omega + 15\,\Omega$

$= 30\,\Omega$

$\Rightarrow 60\,V = 30\,\Omega\, I \Rightarrow I = 2.0\,A$

b) For each $\Delta V_i = I R_i$

$\Delta V_1 = I R_1 = 2.0\,A \times 10\,\Omega = 20\,V$

$\Delta V_2 = I R_2 = 2.0\,A \times 5\,\Omega = 10\,V$

$\Delta V_3 = I R_3 = 2.0\,A \times 15\,\Omega = 30\,V$

c) For each resistor $P_i = I \Delta V_i$

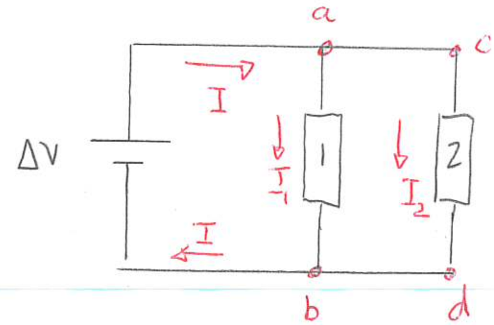
$P_1 = 2.0\,A \times 20\,V = 40\,W$

$P_2 = 2.0\,A \times 10\,V = 20\,W$

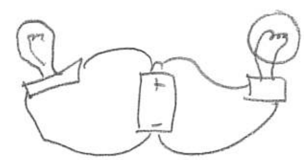
$P_3 = 2.0\,A \times 30\,V = 60\,W$

Parallel Circuits

Two or more devices can be connected in parallel. This is illustrated. In this circuit the current splits at a and rejoins at b.



Parallel circuits are the common household circuits



Immediately we see:

> The current from the power supply splits in a parallel circuit.

The example has $I = I_1 + I_2$. The question of potential differences is possibly less obvious.

Quiz 1 50%

We can address this using the outer loop.

$$\Delta V_{a\to b} + \cancel{\Delta V_{b\to d}}^{0} + \Delta V_{d\to c} + \cancel{\Delta V_{c\to a}}^{0} = 0$$

$$\Rightarrow \Delta V_{a\to b} = -\Delta V_{d\to c} \quad \Rightarrow \quad \Delta V_{a\to b} = \Delta V_{c\to d}$$

Thus

> The potential differences across two or more devices in parallel are all equal.

For resistors Ohm's Law again applies:

$$\Delta V_i = I_i R_i = \Delta V$$

and since R_i will differ, I_i will differ.

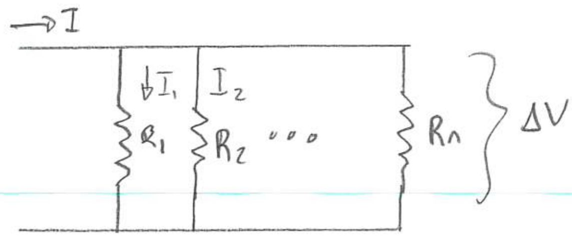
We can obtain the current provided by the battery using

For resistors in parallel

$$\Delta V = I R_{eq}$$

where the equivalent resistance is obtained via

$$1/R_{eq} = 1/R_1 + 1/R_2 + \dots + 1/R_n$$



Warm up 2

Note $R_1 = R_2 = R$

$$\frac{1}{R_{eq}} = \frac{1}{R} + \frac{1}{R} = \frac{2}{R} \Rightarrow R_{eq} = R/2$$

Quiz 2