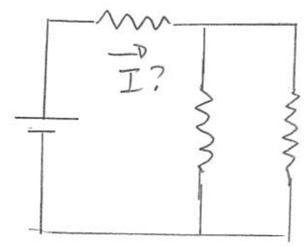
Tues: Lecture

Weds: Discussion/quiz

Ex 106, 109, 111, 112, 114, 115

Series and parallel resistor combinations

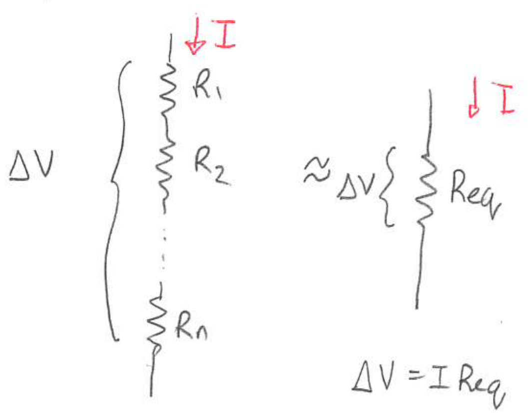
In general circuits will feature various series and parallel combinations of elements. We would like methods for determining currents and potential differences in such circuits.



Quiz 1 ~10%

The strategy will be to replace collections of resistors by single equivalent resistors.

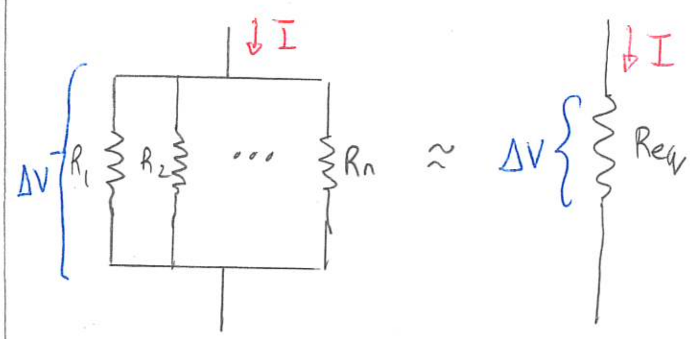
Series



$\Delta V = I R_{eq}$

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

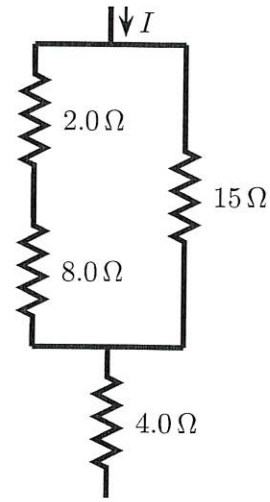
Parallel.



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

107 Equivalent resistance

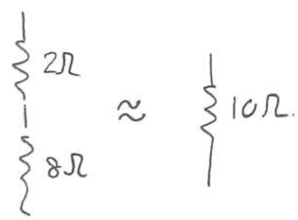
Determine the equivalent resistance of the illustrated resistor combination.



Answer: The approach is:

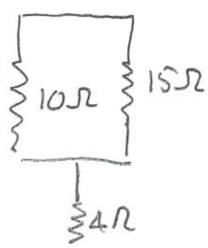
1) replace any series combination
2) replace any parallel "
3) repeat

First



Thus

Circuit ≈

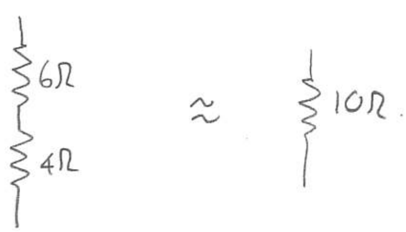


Now

$$\frac{1}{R_{eq}} = \frac{1}{10\Omega} + \frac{1}{15\Omega} = \frac{5}{30\Omega} = \frac{1}{6\Omega}$$

$$\Rightarrow R_{eq} = 6\Omega$$

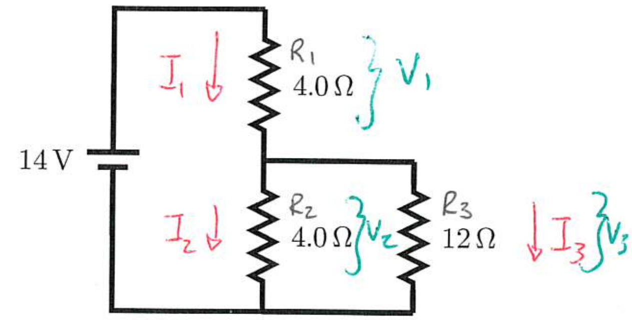
Thus the circuit is equivalent to



Quiz 2 – 80%
– 100%

108 Resistors in series and parallel

Determine the currents through, voltages across and the power dissipated by each resistor in the illustrated circuit.



Label the currents as illustrated.

Note that $I_1 = I_2 + I_3$

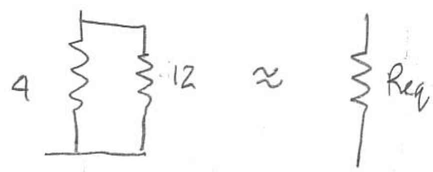
Label the voltages as illustrated.

Then $\Delta V_2 = \Delta V_3$ and $\Delta V_1 + \Delta V_2 = 14V$

We can get I_1 by finding an equivalent resistance and using

$\Delta V = I R_{eq} \Rightarrow \quad 14V = I_1 R_{eq}$.

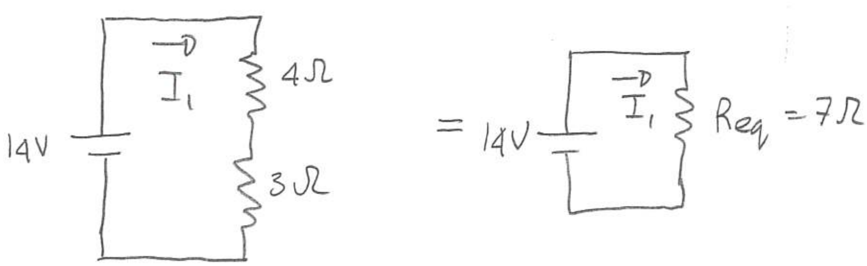
To get R_{eq}.



$$\frac{1}{R_{eq}} = \frac{1}{4} + \frac{1}{12} = \frac{4}{12} = \frac{1}{3}$$

$R_{eq} = 3\Omega$.

So the entire combination amounts to



Then $\Delta V = I_1 R_{eq} \Rightarrow 14V = I_1\, 7\Omega \Rightarrow \quad I_1 = 2.0A$

Now $\Delta V_1 = I_1 R_1 \Rightarrow \Delta V_1 = 2.0A \times 4.0\Omega = 8.0V$

Now $\Delta V_1 + \Delta V_2 = 14V \Rightarrow \Delta V_2 = 6.0V$.

Then

$\Delta V_2 = I_2 R_2 \Rightarrow 6.0V = I_2\, 4.0\Omega$

$\Rightarrow I_2 = 1.5A$

$\Delta V_3 = I_3 R_3 \Rightarrow 6.0V = I_3\, 12\Omega$

$\Rightarrow I_3 = 0.5A$

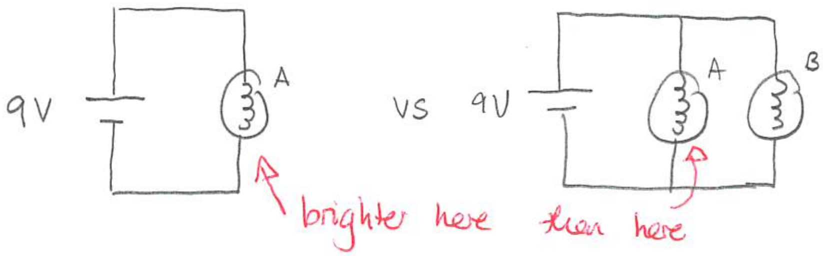
Resistor	ΔV	I	P
1	8.0V	2.0A	16W
2	6.0V	1.5A	8.0W
3	6.0V	0.5A	3.0W

For each resistor $P = I \Delta V$

Quiz 3 10% ~50%

Real batteries

In a real parallel circuit the current in any single device does actually depend on the other devices connected. In theory the potential difference across A in each circuit should be the same. Thus the currents should be the same. Why is this not the case?

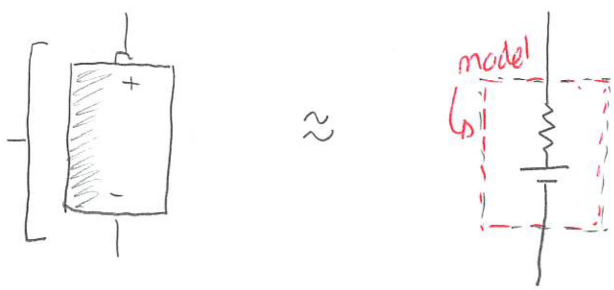


An idealized battery / power supply:

1) offers no resistance to any current
2) can deliver unlimited current.

In practice neither is true. We consider models of batteries that have internal resistance

Actual voltage delivered ΔV

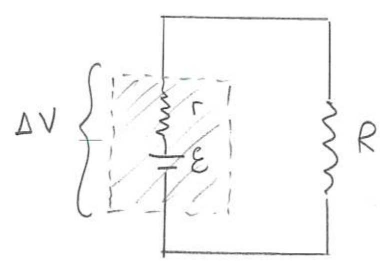


internal resistance r

perfect battery whose potential difference (EMF) is $\mathcal{E}$.

Consider this connected to an external resistor with resistance R. Then

$$\mathcal{E} = I(r+R) \implies I = \frac{\mathcal{E}}{r+R}$$



Now
$$\Delta V = IR$$
$$= \frac{\mathcal{E}}{r+R} R$$

$$\implies \Delta V = \frac{R}{r+R}\,\mathcal{E}$$

actual voltage delivered

→ ideal voltage

→ factor that reduces ideal voltage depends on load resistance

→ circuit operation depends on load.