Name:_____

Simplifying Complicated Circuits

8.6

Difficult circuits can be simplified by finding obvious places where resistors are in series or in parallel. By redrawing the circuit and replacing the original resistors with a single equivalent resistor it will look simpler.

In the following example it should be obvious that the 2, 3 and 2 Ω resistors (on the right) are in series and can be easily added together. Notice that there is a split at letter B. That means that the 4 Ω resistor and the 2, 3 and 2 Ω resistors are in parallel. By the same logic, the split at letter A shows the start of another set of parallel branches. This circuit will become obvious by reducing it step-by-step.

Step 1: The 2, 3, and 2 Ω are in series.

$$R_{Total} = 2 + 3 + 2 = 7\ \Omega$$

Step 2: The 4 Ω and 7 Ω are in parallel.

$$\frac{1}{R_T} = \frac{1}{4} + \frac{1}{7} = .393 \qquad R_T = \frac{1}{.393} = 2.54\ \Omega$$

Step 3: The 3 Ω, 2.54 Ω, and 3 Ω are in series.

$$R_T = 3 + 2.54 + 3 = 8.54\ \Omega$$

Step 4: The 3 Ω and 8.54 Ω are in parallel.

$$\frac{1}{R_T} = \frac{1}{3} + \frac{1}{8.54} = .45 \qquad R_T = \frac{1}{.45} = 2.22\ \Omega$$

Step 5: All resistors and batteries are in series.

$$R_T = 5 + 2.22 + 4 = 11.22\ \Omega$$
$$V_T = 12 + 6 = 18\ v$$

Equivalent Circuit

The entire circuit reduces to a 18 v battery and a 11.22 Ω resistor.

$$I_{Total} = \frac{V_T}{R_T}$$

$$I_{Total} = \frac{18}{11.22} = 1.6A$$

Now that the total current is known it is a simple, though tedious, process to work backwards through the circuit to find the current and/or voltage across each individual resistor in the circuit.
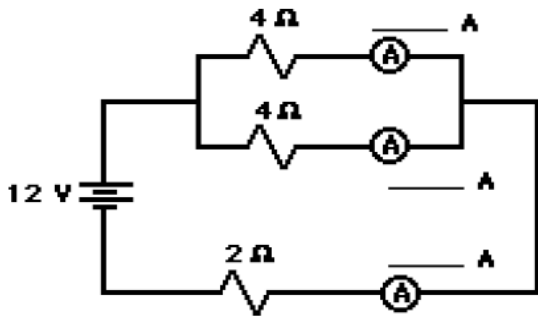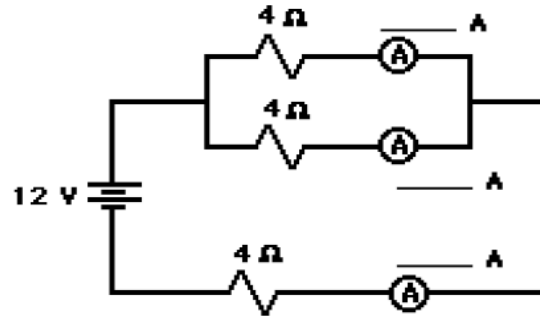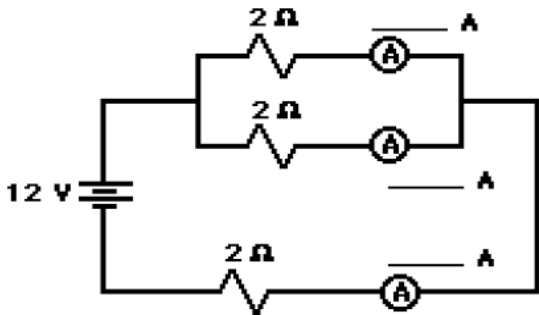
The circuits below are known as combination or compound circuits; they are composed of resistors that are arranged both in parallel with each other as well as other resistors arranged in series with each other. In each circuit, the resistors that are arranged in parallel have the same resistance value. For each combination circuit shown below, determine the equivalent resistance for the combination of three resistors, the total current (i.e., at the battery), and the current at each of the three indicated locations.

4 Ω
___ A
4 Ω
12 V
2 Ω ___ A
___ A

R$_{eq}$ = _____
I$_{tot}$ = _____

4 Ω
___ A
4 Ω
12 V
4 Ω ___ A
___ A

R$_{eq}$ = _____
I$_{tot}$ = _____

2 Ω
___ A
2 Ω
12 V
2 Ω ___ A
___ A

R$_{eq}$ = _____
I$_{tot}$ = _____

2 Ω
___ A
2 Ω
12 V
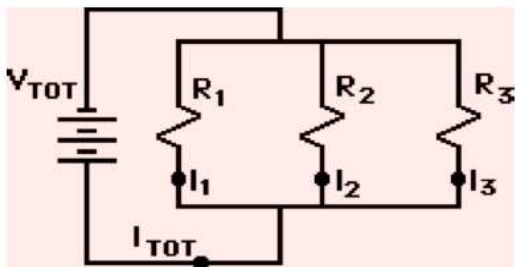4 Ω ___ A
___ A
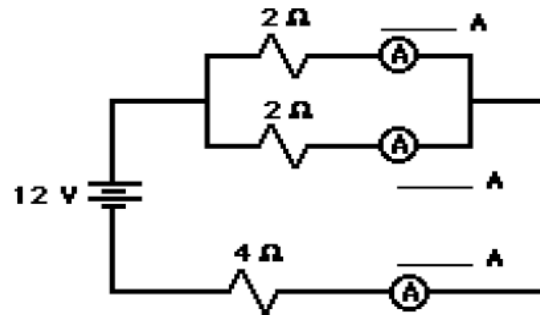
R$_{eq}$ = _____
I$_{tot}$ = _____

Fill in the blanks in the following diagram. Show appropriate units.

V$_{TOT}$ R$_1$ R$_2$ R$_3$
I$_1$ I$_2$ I$_3$
I$_{TOT}$

V$_{Tot}$ = 60.0 V

R$_1$ = 12.5 Ω   R$_2$ = 14.7 Ω   R$_3$ = 19.1 Ω

R$_{Tot}$= _____   I$_{Tot}$ = _____

ΔV$_1$= _____   I$_1$ = _____

ΔV$_2$= _____   I$_2$ = _____

ΔV$_3$= _____   I$_3$ = _____

Fill in the blanks in the following diagram. Show appropriate units.

R$_1$ I$_1$
V$_{TOT}$ R$_2$
I$_2$
I$_3$ R$_3$

V$_{Tot}$ = 60.0 V

R$_1$ = 12.5 Ω   R$_2$ = 14.7 Ω   R$_3$ = 19.1 Ω

R$_{Tot}$= _____   I$_{Tot}$ = _____

ΔV$_1$= _____   I$_1$ = _____

ΔV$_2$= _____   I$_2$ = _____

ΔV$_3$= _____   I$_3$ = _____