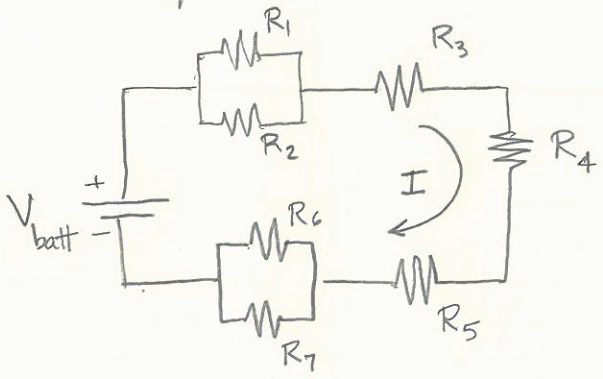
EAS 199A Example of DC Circuit Analysis

For the circuit represented by the schematic to the right, determine

a.) The current, I

b.) The power supplied by the battery

c.) The voltage across R_5



Use the following numerical values for the circuit parameters

$V_{batt} = 120\,V$

$R_1 = R_2 = 20\,\Omega$

$R_3 = 5\,\Omega$

$R_4 = 10\,\Omega$

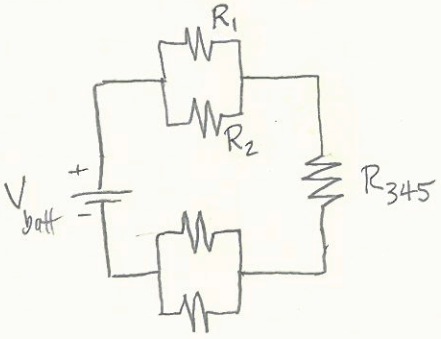
$R_5 = 15\,\Omega$

$R_6 = 25\,\Omega$

$R_7 = 100\,\Omega$

Note: The Given and Find steps in the standard format are not necessary because that information is provided in the problem statement. More interesting problems require the Given and Find steps to be part of the problem-definition phase of problem-solving

Solution: First combine the resistors in series

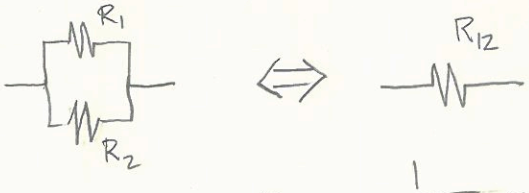


$$R_{345} = R_3 + R_4 + R_5$$

$$= 5\,\Omega + 10\,\Omega + 15\,\Omega$$

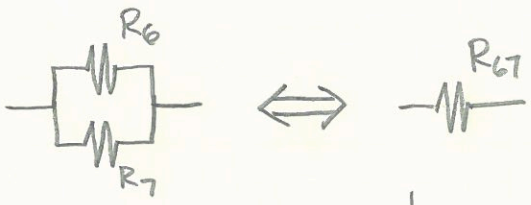
$$\boxed{R_{345} = 30\,\Omega}$$

Combine the resistors in parallel



$\therefore R_{12} = 10\,\Omega$

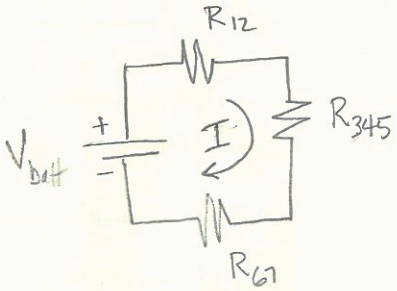
$$R_{12} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}} = \frac{1}{\frac{1}{20\,\Omega} + \frac{1}{20\,\Omega}} = \frac{1}{\frac{2}{20\,\Omega}} = 10\,\Omega$$



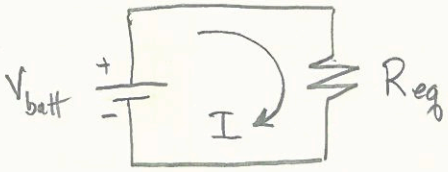
$$R_{67} = \frac{1}{\frac{1}{R_6} + \frac{1}{R_7}} = \frac{1}{\frac{1}{25\Omega} + \frac{1}{100\Omega}} = \frac{1}{\frac{5}{100\Omega}} = 20\Omega$$

$$\therefore R_{67} = 20\Omega$$

Replacing the parallel resistors with their equivalent values gives the following equivalent circuit



Combine the resistors in series:



$$R_{eq} = R_{12} + R_{345} + R_{67}$$

$$= 10\Omega + 30\Omega + 20\Omega$$

$$\therefore R_{eq} = 60\Omega$$

Apply Ohm's law to the simplified circuit and solve for I

$$V_{batt} = I R_{eq} \Rightarrow I = \frac{V_{batt}}{R_{eq}} = \frac{120\,V}{60\Omega} = 2\,A$$

$$\therefore \boxed{I = 2A}$$

b.) Compute the power supplied by the battery

Use the most simplified version of the circuit

$$P_{batt} = V_{batt} I = (120V)(2A) = 240W$$

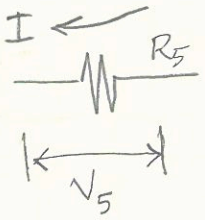
$$\boxed{P_{batt} = 240W}$$

c.) Voltage drop across R_5 is obtained by applying Ohm's Law

Refer to the original circuit diagram.

The current I flows through R_3, R_4 and R_5

Isolate R_5:



$$V_5 = I R_5 = (2A)(15\Omega)$$

$$= 30V$$

$$\boxed{V_5 = 30V}$$

Discussion

The results seem plausible

- R_{345} is greater than any of the resistors used in the series combination
- R_{12} is less than R_1 or R_2
- R_{67} is less than R_6 or R_7

The voltage across R_5 is less than the voltage across the battery.

MathCAD solution to the Series and Parallel Resistor Analysis
EAS 199A Lecture #2

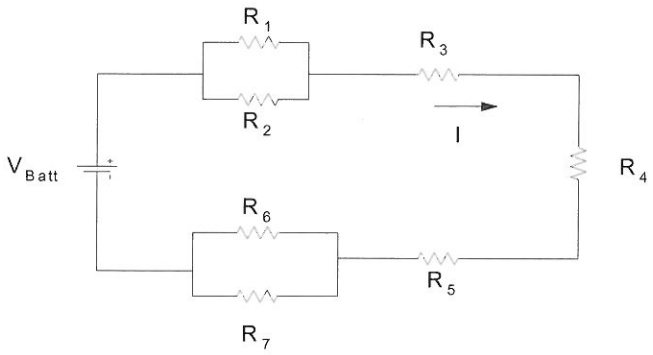
Given The circuit as drawn on the right.

$V_{Batt} := 120V$ $R_4 := 10ohm$

$R_1 := 20ohm$ $R_5 := 15ohm$

$R_2 := 20ohm$ $R_6 := 25ohm$

$R_3 := 5ohm$ $R_7 := 100ohm$



Find

(a) the current (I)
(b) the power supplied by the battery
(c) the voltage across R_5

Note to class: the figure was drawn in Microsoft Visio. You can add a drawing to a MathCAD worksheet by scanning it and placing the image in the worksheet, or by hand-drawing the circuit on a printout of the worksheet.

Solution

(a) Find the current (I)

First, combine all resistors in series

$R_{345} := R_3 + R_4 + R_5$

$R_{345} = 30\,\Omega$

Note to class - define a value by typing the variable name followed by a colon. This is an assignment statement. Find out the result of a calculation by typing the variable name followed by the equals sign.

Combining all resistors in parallel, we find that

$$R_{12} := \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}} \qquad R_{67} := \frac{1}{\frac{1}{R_6} + \frac{1}{R_7}}$$

$R_{12} = 10\,\Omega$ $R_{67} = 20\,\Omega$

Noting that R_{345}, R_{12}, and R_{67} are now in series, we can calculate the overall equivalent resistance (R_{eq}) as follows:

$R_{eq} := R_{12} + R_{345} + R_{67}$

$R_{eq} = 60\,\Omega$

With R_{eq} known, we apply Ohm's law on the simplified circuit to compute the current, I, leaving the battery

$$I := \frac{V_{Batt}}{R_{eq}}$$

$I = 2\ A$

Note to class- highlight an answer by clicking on the Format menu, then Properties, and then click the check box "Highlight Properties."

(b) Find the power supplied by the battery

$$P_{Batt} := V_{Batt} \cdot I$$

$P_{Batt} = 240\ W$

(c) Find the voltage drop across R_5

$$V_{R5} := I \cdot R_5$$

$V_{R5} = 30\ V$

Discussion

The answers seem reasonable.

The combinations of series resistors resulted in equivalent resistances greater in value than any single resistance, as expected.

The combinations of parallel resistors resulted in equivalent resistances less than the value of any single resistance, as expected.

The voltage acros R_5 was less than the voltage supplied by the battery, as expected.