Mr. Renwick's Physics 12 — Name: Answer Key
Worksheet – Electric Circuits 3 – Solving Resistor Circuits — Block: ______

Learning Intentions

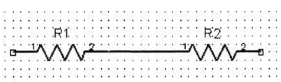
- How to calculate the equivalent resistance in resistors placed in parallel and in series.
- The rules for finding the voltage and current through resistors in complex circuits.

Notes and Vocabulary

1. Electric load is the part of a circuit that consumes electric power.

2. The equivalent resistance is the "total" resistance of a circuit.

3. In series, the equivalent resistance is found by adding resistances according to the formula

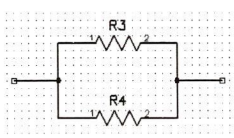


$R_{eq} = \Sigma R_i = R_1 + R_2 + \ldots$

   a. If R1 is 150 Ω and R2 is 100 Ω, what is the equivalent resistance of the circuit above?

   $R_{eq} = R_1 + R_2 = 150\,\Omega + 100\,\Omega = 250\,\Omega$

4. In parallel, the equivalent resistance is found according to the formula



$\frac{1}{R_{eq}} = \Sigma \frac{1}{R_i} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$

   a. If R3 is 150 Ω and R4 is 100 Ω, what is the equivalent resistance of the circuit above?

   $\frac{1}{R_{eq}} = \frac{1}{R_3} + \frac{1}{R_4} = \frac{1}{150\,\Omega} + \frac{1}{100\,\Omega} = \frac{1}{60\,\Omega} \Rightarrow R_{eq} = \left[\frac{1}{60\,\Omega}\right]^{-1} = 60\,\Omega$

5. There are 3 important rules for resistor circuits

   a. Ohm's Law (from last class)

   $V = I \cdot R$ — current (I), resistance (Ω, R), voltage (V)

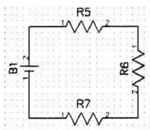
   b. Kirchhoff's Voltage Rule:

      i. The Theory of Conservation of Energy says that the voltage increase at the battery is equal to the voltage decrease through the load.

See over →

ii. This law is also known as Kirchhoff's Loop rule, because it states that the

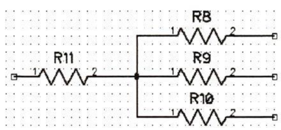
voltage changes around a circuit add to zero.



$V_{B1} - V_{R5} - V_{R6} - V_{R7} = 0$

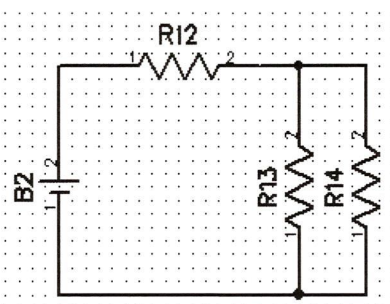
c. Kirchhoff's Junction Rule:

i. Electric current (I, in Amps) is the flow of electrons, so the total flow of electrons into a node (or junction) has to equal the total flow of electrons out of of the node.



$I_{R1} = I_{R8} + I_{R9} + I_{R10}$

6. In high school, you are expected to solve circuit problems by finding the equivalent resistance.

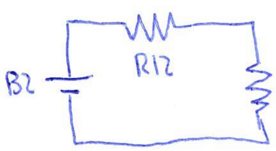


Look at R13 and R14 to start (start with parallel)

$\frac{1}{R_{eq1}} = \frac{1}{R_{13}} + \frac{1}{R_{14}} = \frac{1}{50\,\Omega} + \frac{1}{400\,\Omega}$

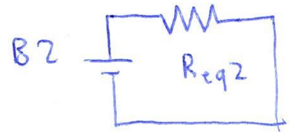
$R_{eq1} = \left[\frac{1}{50\,\Omega} + \frac{1}{400\,\Omega}\right]^{-1} = 44\,\Omega$

The circuit then simplifies



$R_{eq2} = R_{12} + R_{eq1} = 75\,\Omega + 44\,\Omega = 119\,\Omega$

And the circuit becomes



$V_{B2} - V_{Req2} = 0$

$V_{Req2} = V_{B2} = 5.0\,V$

$I_{Req2} = \frac{V_{Req2}}{R_{eq2}} = \frac{5.0\,V}{119\,\Omega} = 0.042\,A$

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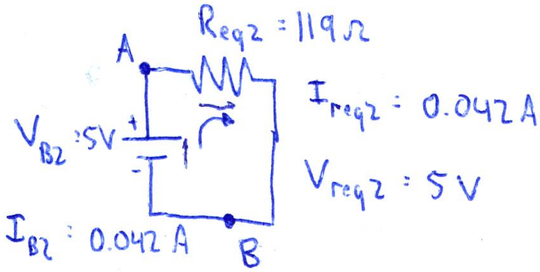
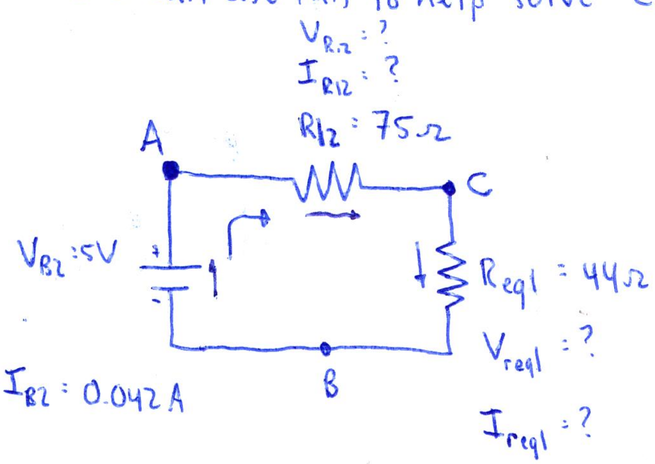
This is a lengthy and tedious process. We will use computers instead.

We now know everything about Circuit 3



We can use this to help solve Circuit 2



Looking at Node A

$I_{B2} - I_{R12} = 0$

$I_{R12} = I_{B2} = 0.042A$

Looking at Node B

$I_{req1} - I_{B2} = 0$

$I_{req1} = I_{B2}$

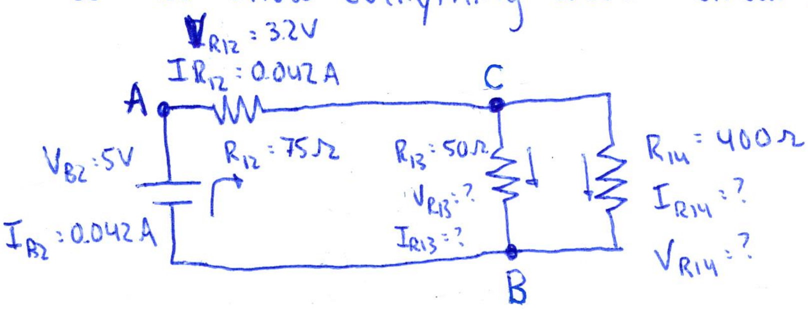
Applying Ohm's Law

$V_{R12} = I_{R12} \times R_{12} = 0.042A \times 75\Omega = 3.2V$

$V_{req1} = I_{req1} \times R_{eq1} = 0.042A \times 44\Omega = 1.8V$

$3.2V + 1.8V = 5.0V = V_{B2}$

We now know everything about Circuit 2, and use it to solve Circuit 1



Looking at the loop through B2, R12, and R13

$$V_{B2} - V_{R12} - V_{R13} = 0$$

$$V_{R13} = V_{B2} - V_{R12} = 5V - 3.2V = 1.8V$$

Looking at the loop through B2, R12, and R14 <u>OR</u> the loop through R13 and R14

$$V_{B2} - V_{R12} - V_{R14} = 0 \qquad V_{R13} - V_{R14} = 0$$

$$V_{R14} = V_{B2} - V_{R12} = 5V - 3.2V = 1.8V \qquad V_{R14} = V_{R13} = 1.8V$$

All this work above (↑) can be avoided by recognizing that $V_{R13} = V_{R14} = V_{req1}$ because they all have the same voltage drops from Node C to Node B.

To find current, we use Ohm's Law

$$I_{R13} = \frac{V_{R13}}{R_{13}} = \frac{1.8V}{50\Omega} = 0.036A$$

$$I_{R14} = \frac{V_{R14}}{R_{14}} = \frac{1.8V}{400\Omega} = 0.0045A$$

$$I_{R13} + I_{R14} = 0.041A = I_{req1}$$

We have now solved the whole circuit.