PHYSICS IN MOTION
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Unit 5H
Parallel and Complex Circuits
Practice Problems TEACHER

Work each of the following problems. SHOW ALL WORK.

1. Three 6 Ω resistors are wired in parallel. What is the equivalent resistance of these three resistors?

$$R_1 = R_2 = R_3 = 6\ \Omega$$

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{1}{R_{eq}} = \frac{1}{6\ \Omega} + \frac{1}{6\ \Omega} + \frac{1}{6\ \Omega}$$

$$\frac{1}{R_{eq}} = \frac{3}{6\ \Omega}$$

$$\frac{R_{eq}}{1} = \frac{6\ \Omega}{3}$$

$$R_{eq} = 2\ \Omega$$

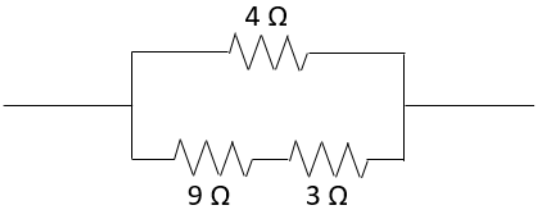
2. What is the equivalent resistance between the two terminals in the diagram below?

The 9 Ω resistor and the 3 Ω resistor are in series, so:

$$R_{eq} = R_{9\Omega} + R_{3\Omega}$$

$$R_{eq} = 9\ \Omega + 3\ \Omega$$

$$R_{eq} = 12\ \Omega$$



This is in parallel with the 4 Ω resistor:

$$R_1 = 4\ \Omega$$

$$R_2 = 12\ \Omega$$

For resistors in parallel:

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

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

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

$$\frac{1}{R_{eq}} = \frac{4}{12\ \Omega}$$

$$\frac{R_{eq}}{1} = \frac{12\ \Omega}{4}$$

$$R_{eq} = 3\ \Omega$$

questions continued on next page

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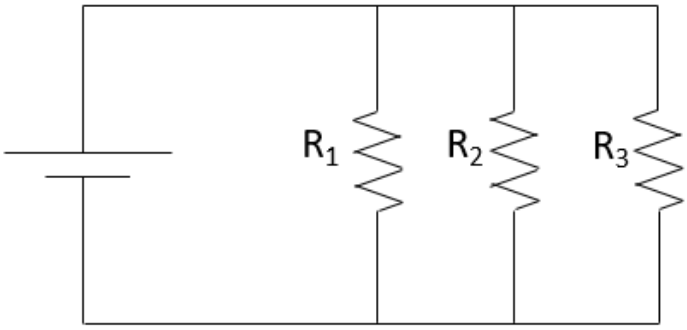
Work each of the following problems. SHOW ALL WORK.

3. Complete the VIR chart for the circuit below:



	V (V)	I (A)	R (Ω)
Resistor 1	*9*	*4.5*	**2**
Resistor 2	*9*	*3*	**3**
Resistor 3	*9*	*2.25*	**4**
Total	**9**	*9.75*	*0.92*

As each of the three resistors is on its own branch and they are in parallel to one another, they all receive 9 V of potential difference. Use Ohm's law to determine the current in each branch:

$$I_1 = \frac{V}{R_1} = \frac{9\,V}{2\,\Omega} = 4.5\,A$$
$$I_2 = \frac{V}{R_2} = \frac{9\,V}{3\,\Omega} = 3\,A$$
$$I_3 = \frac{V}{R_3} = \frac{9\,V}{4\,\Omega} = 2.25\,A$$

The total current in the circuit is the sum of the currents in each branch, which is 9.75 A. To find the total resistance of the circuit, use Ohm's law and divide the potential difference by the total current in the circuit:

$$R_{eq} = \frac{V_{Tot}}{I_{Tot}} = \frac{9\,V}{9.75\,A} = 0.92\,\Omega$$

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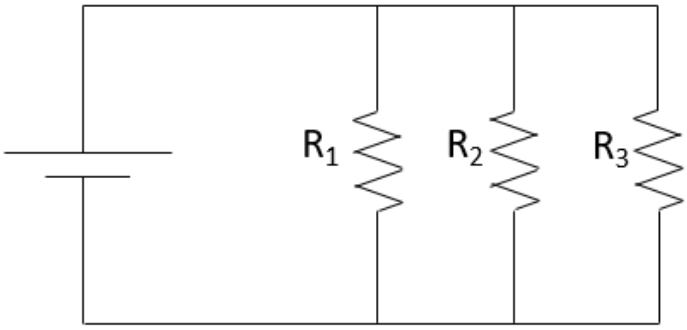
Work each of the following problems. SHOW ALL WORK.

4. Complete the VIR chart for the circuit below:



	V (V)	I (A)	R (Ω)
Resistor 1	*6*	*3*	**2**
Resistor 2	**6**	*1*	*6*
Resistor 3	*6*	*2*	**3**
Total	*6*	**6**	*1*

As each of the three resistors is on its own branch and they are in parallel to one another, they all receive 6 V of potential difference, which is the total potential difference in the circuit. Use Ohm's law to determine the currents in branches 1 and 3:

$$I_1 = \frac{V}{R_1} = \frac{6\,V}{2\,\Omega} = 3\,A$$

$$I_3 = \frac{V}{R_3} = \frac{6\,V}{3\,\Omega} = 2\,A$$

Knowing the total current in the circuit is the sum of the currents in each branch, determine the current in branch 2:

$$I_{Tot} = I_1 + I_2 + I_3$$
$$6\,A = 3\,A + I_2 + 2\,A$$
$$6\,A = I_2 + 5\,A$$
$$I_2 = 1\,A$$

Knowing the current and potential difference in branch 2, determine the resistance:

$$R_2 = \frac{V}{I_2} = \frac{6\,V}{1\,A} = 6\,\Omega$$

To find the total resistance of the circuit, use Ohm's law and divide the potential difference by the total current in the circuit:

$$R_{eq} = \frac{V_{Tot}}{I_{Tot}} = \frac{6\,V}{6\,A} = 1\,\Omega$$

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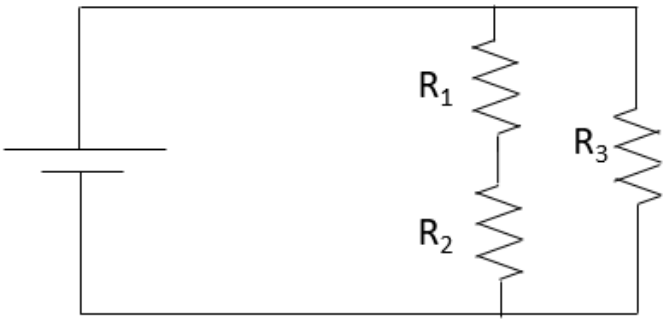
Work each of the following problems. SHOW ALL WORK.

5. Complete the VIR chart for the circuit below:



	V (V)	I (A)	R (Ω)
Resistor 1	*3*	*3*	**1**
Resistor 2	*6*	**3**	**2**
Resistor 3	*9*	*1*	*9*
Total	*9*	**4**	*2.25*

Resistors 1 and 2 are in series, so they will have the same current of 3 A.
Use Ohm's law to determine the potential differences across resistors 1 and 2:

$$V_1 = I_1 R_1 = (3\ A)(1\ \Omega) = 3\ V$$
$$V_2 = I_2 R_2 = (3\ A)(2\ \Omega) = 6\ V$$

The total potential difference in the branch is the sum of the potential differences in each of the resistors, so the total potential difference in the branch is 9 V.

Both the potential difference in the parallel branch and the total potential difference for the circuit are also 9 V.

Knowing that the total current in the circuit is the sum of the currents in each branch, determine the current through resistor 3:

$$I_{Tot} = I_{1\,and\,2} + I_3$$
$$4\ A = 3\ A + I_3$$
$$I_3 = 1\ A$$

Use Ohm's law to determine the resistance of resistor 3:

$$R_3 = \frac{V_{Tot}}{I_3} = \frac{9\ V}{1\ A} = 9\ \Omega$$

Use Ohm's law to determine the total resistance of the circuit:

$$R_{eq} = \frac{V_{Tot}}{I_{Tot}} = \frac{9\ V}{4\ A} = 2.25\ \Omega$$

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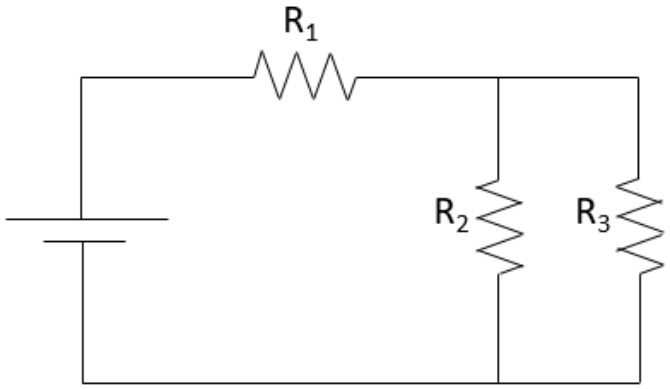
Work each of the following problems. SHOW ALL WORK.

6. Complete the VIR chart for the circuit below:



	V (V)	I (A)	R (Ω)
Resistor 1	*8*	*2*	**4**
Resistor 2	*4*	**0.5**	*8*
Resistor 3	*4*	**1.5**	*2.67*
Total	**12**	**2**	*6*

The current through resistor 1 must be the same as the total current of the circuit (2 A) because it is in series with the battery. Use Ohm's law to determine the potential difference across resistor 1:

$$V_1 = I_1 R_1 = (2\ A)(4\ \Omega) = 8\ V$$

The remaining potential difference is 4 V, and the two parallel branches will each receive 4 V of potential difference. Use Ohm's law to determine the resistance values of resistors 2 and 3:

$$R_2 = \frac{V_2}{I_2} = \frac{4\ V}{0.5\ A} = 8\ \Omega$$

$$R_3 = \frac{V_3}{I_3} = \frac{4\ V}{1.5\ A} = 2.67\ \Omega$$

Use Ohm's law to determine the total resistance of the circuit:

$$R_{eq} = \frac{V_{Tot}}{I_{Tot}} = \frac{12\ V}{2\ A} = 6\ \Omega$$