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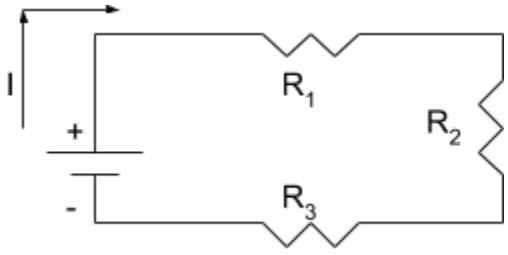
Physics Unit: DC Circuits
Worksheet 1: Series Circuits

DC Circuits: DC circuits are simply those in which the current moves in one direction only (thus direct current – DC). Anything that runs on batteries is using DC. If you plug something in the wall it runs on AC (although some devices internally convert the AC (alternating current) into DC).

In a DC circuit, the positive charges (wink, wink) leave the positive terminal of the battery with a large amount of potential energy. That energy must be converted into some other type before the charges make it to the negative side of the battery. A resistor converts the potential energy into thermal energy which the resistor dissipates as heat. A motor converts the potential energy into work. A light bulb converts the energy into light and heat. You get the idea.



Series Circuits: Series circuits are those in which there is only one conductive path between the positive and negative terminals as shown in the diagram to the right. We show current coming out of the positive end of the terminal, but remember that the current starts everywhere in the circuit (essentially) at once. The symbol ⩘⩘ stands for a resistor. The idea is that the zig-zags make it more difficult for current to make it through. Real resistors are not just bent sections of wire. The resistors in the diagram are labeled so that we can distinguish them.

Each resistor in a series circuit adds to the total resistance. Thus the total resistance of a series circuit can be found by

$$R_s = R_1 + R_2 + R_3 + \ldots + R_n = \sum_i R_i$$

Questions

1. What is the total resistance of a series circuit if the circuit contains 3 resistors of values 3 Ω, 7 Ω, and 20 Ω? $R_{tot} = R_1 + R_2 + R_3 = 3 + 7 + 20 = 30\,\Omega$

2. ~~A 10 Volt power source~~ is connected to a series of 5 10-Ω resistors. What is the total resistance? $R_{tot} = R_1 + R_2 + \ldots = 5 \cdot 10 = 50\,\Omega$

3. A series circuit with three resistors (R_1, R_2, R_3) has a total resistance of 3000 Ω. If the resistors are such that $R_1 = R_2$ and $R_3 = 2R_1$, what is the value of R_3? $R_1 = \frac{3000}{4} = 750\,\Omega$ $R_1 + R_2 + R_3 = 3000 = R_1 + R_1 + 2R_1 = 4R_1$ $R_3 = 2 \cdot R_1 = 1500$

4. A 10 Volt power source is connected to a series of 5 10-Ω resistors. What is the total

$R_{tot} = 50$ $V = IR$ $I = \frac{V}{R} = \frac{10}{50} = 0.2\,A$

current? (You might have to look back to the last chapter if you don't remember.)

Continued on next page

5. The circuit in the diagram from the previous page has three resistors and 4 wires connecting the resistors and the battery. If each wire is 1 foot of 26 gauge copper wire then each has a resistance of about 0.041 Ω. Note that the wires are in series with the resistors. $R_w = 4 \cdot 0.041$ $R_{rs} = 3 \cdot 100$ $R = 300 + 0.164 = 300.164$

a. If each resistor has a resistance of 100 Ω, what is the resistance of the total circuit?

b. What fraction of the total resistance is caused by the wires?

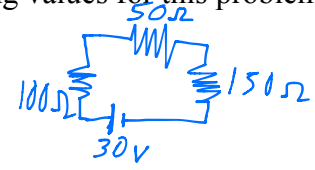
$0.164/300.164 = A$ Very small number (R of wires is negligable.)

Current in the Series Circuit: In a series circuit there is only one pathway for the current. In the diagram on the previous page, a single positive charge leaving the positive terminal battery must move through R_1, then R_2 and then R_3 losing some of its potential energy in each resistor. (Note: The wires connecting the resistors should have very tiny amounts of resistance and thus should add very little to the total resistance.) Thus, **each series resistor receives the same amount of current**. In fact, if 30 mA were to leave the battery, then each of the resistors would have 30 mA of current running through it.

Ohm's Law: Ohm's law (**V= IR**) can be applied to each resistor as well as to the circuit as a whole. If a circuit has a total resistance of 5 Ω and a battery of 10 V, then the current leaving the battery is 2 A. Each resistor in the circuit would then have 2 A of current running through it. We can then calculate the potential difference across each resistor by using V = IR again but now with that resistor only. Adding the voltage drop across each resistor gives us the total voltage drop for the whole circuit which should be equal to the battery voltage. When applying V=IR to a single resistor you have to realize that V is the potential difference across that resistor only.

Power: **P = IV** also works for the whole circuit as well as for each individual part of the circuit. Again, if dealing with a single resistor, each of the terms must apply to that resistor only.

6. Draw a circuit with a battery and three resistors in series. The resistor closest to the positive terminal is R_1 and the one closest to the negative terminal is R_3. Use the following values for this problem: $V_{battery}$ = 30 V, R_1 = 100 Ω, R_2 = 50 Ω and R_3 = 150 Ω.



a. What is the net resistance of the circuit? R_{net} = 300 Ω

b. What is the current leaving the battery? I_{net} = $\frac{V}{R} = 0.1A$

c. What is the power produced by the battery? P_{net} = IV = 3w

d. What is the current through each resistor? I_1 = 0.1A, I_2 = 0.1A, I_3 = 0.1 A

e. What is the voltage drop across each resistor? V_1 = $IR_1 = 10v$, V_2 = $IR_2 = 5$, V_3 = $IR_3 = 15$

f. What is the power dissipated by each resistor? P_1 = $IV_1 = 1w$, P_2 = $IV_2 = 0.5$, P_3 = $IV_3 = 1.5$

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7. In a series circuit, which resistor gets the most current? All =
8. In a series circuit, which resistor causes the largest voltage drop? One with largest resistance.
9. In a series circuit, which resistor causes energy to dissipate at the greatest rate? One with largest resistance.

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Physics Unit: DC Circuits
Worksheet 2: Parallel Circuits

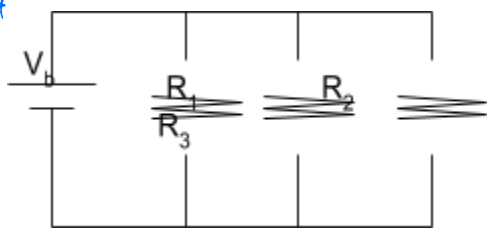
Review:

1. A series circuit has 3 resistors of values 200 Ω, 300 Ω and 700 Ω all connected to a 6-Volt power supply.
   a. What is the total resistance of the circuit? 1200 Ω
   b. What current flows from the battery? $I = \frac{V}{R} = \frac{6}{1200} = 0.005\,A$
   c. What is the current through, voltage across and power dissipated by the 300 Ω resistor? $I = 0.005\,A$ $V = 1.5\,V$ $P = IV = 0.0075\,W$
   d. Which of the values (if any) would be the same for the 700 Ω resistor? Current
   e. What power rating does the battery require to keep the voltage and current constant? 0.03 W

2. What does adding more resistors to a series circuit do to the total resistance? Total current? Total voltage?

Increases ΣR, Decreases ΣI. Voltage is not changed

Parallel Circuits: Parallel circuits are ones in which there are more than one pathway from the positive terminal to the negative terminal. We will start by dealing with problems in which each pathway has only one resistor. Look at the diagram to the right: it shows three resistors connected to a battery rated at a voltage of V_b.



Current leaves the positive side of the battery and eventually comes to a juncture. At this point the current will split, some going through R_1 and some continuing on towards R_2 and R_3. At the next juncture, the remaining current will split again with some moving through R_2 and some moving on to R_3. On the lower side of the circuit, the currents will rejoin and all of the current will return to the battery to get 'reenergized'.

Voltage in the parallel circuit: Each pathway in a true parallel circuit can be considered as being connected directly to the battery. Any charge that flows through R_1 will certainly move back to the battery rather than go through another resistor. For instance, if the battery is rated at 9-Volts, then charges moving through R_1 must lose the full 9 joules per coulomb since there is no where else for the energy to go. This same argument applies to each of the other resistors as well. Thus, **in a parallel circuit, each resistor has the full battery voltage across it** ($\mathbf{V_1 = V_2 = V_3 = V_{battery}}$). Unlike a series circuit, the resistors do not necessarily get the same current since the charges leaving R_1 don't go through R_2.

Resistors in parallel: Adding resistors in parallel is a little tricky. This is because each resistor added in parallel actually **decreases** the total resistance. In fact, the equation we use is to find the reciprocal of the net resistance:

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots \frac{1}{R_n} = \sum_i \frac{1}{R_i}$$

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To find the actual net resistance, you must then take the reciprocal of $1/R_p$ to find R_p.

3. What is the net resistance when two 30 Ω resistors are connected in parallel?

$\frac{1}{30}+\frac{1}{30}=\frac{1}{R_{tot}}$ $R_{tot}=1/\frac{2}{30}=15\Omega$

4. What is the net resistance when three 30 Ω resistors are connected in parallel?

$\sum\frac{1}{R}=\frac{1}{R_{tot}}=\frac{3}{30}$ $R_{tot}=10\Omega$

5. What is the net resistance when five 30 Ω resistors are connected in parallel?

$\sum\frac{1}{R}=\frac{1}{R_{tot}}=\frac{5}{30}$ $R_{tot}=6\Omega$

6. What happens to the net resistance of a parallel circuit when an extra resistor is added? How does this compare with a series circuit?

It decreases. This is the opposite of Series

7. What is the net resistance of a parallel circuit with three resistors of values 1000 Ω, 200 Ω, and 100 Ω?

$\sum\frac{1}{R}=\frac{1}{R_{tot}}=\frac{16}{1000}$ $R_{tot}=62.5$

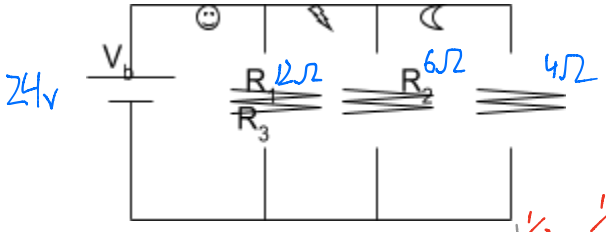
Light bulbs have the same basic effect on a circuit as resistors (in fact, they actually are just thin bare wires that heat up and glow due to electrical resistance).

8. If three bulbs are connected in series and one light burns out, what happens to the others? What if they are in parallel? If in series they all turn off. If parallel, the others stay on.

9. If three bulbs are connected in series and then one extra bulb is connected in series to the others, what happens to the brightness of the others? What if they are in parallel?

Series: All are dimmer. Parallel: All stay the same.

10. The diagram below shows a parallel circuit with three resistors. For the questions below, apply the following values: $V_{battery}$ = 24 V, R_1 = 12 Ω, R_2 = 6 Ω and R_3 = 4 Ω. (Ignore the funny symbols for now)



$\frac{1}{12}+\frac{2}{12}+\frac{3}{12}=\frac{6}{12}=\frac{1}{R}$

a. What is the net resistance of the circuit? R_{net} = 2 Ω

b. What is the current leaving the battery? I_{net} = 12 A

c. What is the power produced by the battery? P_{net} = 288 W

d. What is the voltage drop across each resistor? V_1 = 24 V, V_2 = 24 V, V_3 = 24 V

e. What is the current through each resistor? I_1 = 2 A, I_2 = 4 A, I_3 = 6 A

f. What is the power dissipated by each resistor? P_1 = 48 W, P_2 = 96 W, P_3 = 144

g. What is the current at each of the marked places in the circuit?

I at ☺ = 12 A, I at ✎ = 12-2=10 A, I at ☾ 10-4=6 A

11. In a parallel circuit, which resistor gets the most current?

One with lowest resistance

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12. In a parallel circuit, which resistor causes the largest voltage drop? All =
13. In a parallel circuit, which resistor causes energy to dissipate at the greatest rate?

One with lowest resistance

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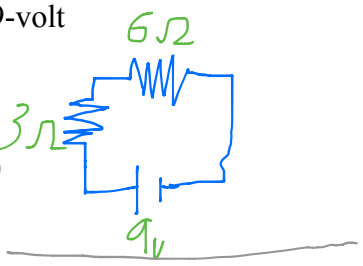
Physics Unit: DC Circuits
Worksheet 3: Series vs Parallel Circuits and Combo's

Review

1. In a series circuit, all resistors receive the same Current?
2. In a parallel circuit, all resistors receive the same Voltage?
3. What current flows through a circuit of total resistance 2400 Ω connected to a 3 Volt battery? $V=IR$ $\frac{3}{2400}=I=\frac{1}{800}=0.00125$

4. A circuit has a 3-Ω and a 6-Ω resistor wired in series and connected to a 9-volt battery. Draw a diagram of the circuit.
   a. What is the total resistance of the circuit? $R=R_1+R_2=3+6=9\Omega$
   b. What current runs through the 3-Ω resistor? $I=\frac{V}{R}=\frac{9V}{9\Omega}=1A$
   c. What is the voltage drop across the 6-Ω resistor? $V=IR=1.6=6V$
   d. What power must the battery produce? $P=IV=1\cdot 9=9W$



5. A circuit has a 3-Ω and a 6-Ω resistor wired in parallel and connected to a 9-volt battery. Draw a diagram of the circuit.
   a. What is the total resistance of the circuit? $\frac{1}{R}=\frac{1}{R_1}+\frac{1}{R_2}=\frac{1}{3}+\frac{1}{6}=\frac{1}{2}$ $R=2\Omega$
   b. What is the voltage drop across the 6-Ω resistor? 9V
   c. What current runs through the 3-Ω resistor? $I=\frac{V}{R}=\frac{9}{3}=3A$
   d. What power must the battery produce? $P=IV=V(I_1+I_2)=9(3+\frac{1}{6})=40.5W$

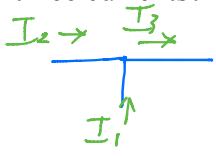
6. An identical set of resistors can be connected in series or in parallel. Which arrangement results in
   a. the largest resistance? Series
   b. the largest current? Parallel
   c. the largest power dissipated? Parallel

Kirchoff's Rules – While a student, G. R. Kirchoff designed a way to help himself remember the behavior of circuits by creating two laws. The first is based on the conservation of charge and the second is based on the conservation of energy:

Kirchoff's 1st Rule or the junction rule - at any junction point, the sum of all currents entering the junction must equal the sum of all currents leaving the junction.

Kirchoff's 2nd Rule or the loop rule – the sum of the changes in potential around any closed path of a circuit must be zero.

7. At a point in a circuit, currents from two wires (I_1 and I_2) combine and flow into a single wire with a current of I_3. What mathematical relationship must exist between these three currents?



$I_1+I_2=I_3$

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8. For the circuit described in problem 4, show that the loop rule is obeyed. This can be done by finding the potential changes across the three elements (the battery and the two resistors. Be sure to include a sign for each change.

$\Delta V_{battery}$ = 9V, $\Delta V_{R=3\,\Omega}$ = -3V, $\Delta V_{R=6\,\Omega}$ = -6V

9-3-6=0 ✓

9. Explain how the junction rule can be used to explain your answer to question 1.

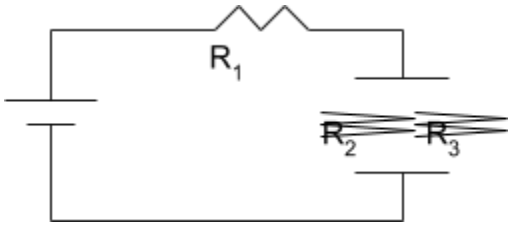
No junctions so nowhere for current to leave.

10. Explain how the loop rule can be used to explain your answer to question 2.

Each parallel part is a separate loop, so $\Delta V =$

Combo Circuits – Some circuits off a combination of series and parallel. They are casually referred to by some as combination circuits but they are really just DC circuits. The difficulty with them lies in the fact that the resistors do neither get all the current (as in series circuits) nor do the get the full voltage drop (as in parallel). One of our goals in dealing with them is find the current, potential drop and power usage for each resistor in the circuit as well as the total resistance, current from the battery and power produced by the battery. For now we will focus on finding the total resistance of the circuit. The simplest combo circuits are shown below.

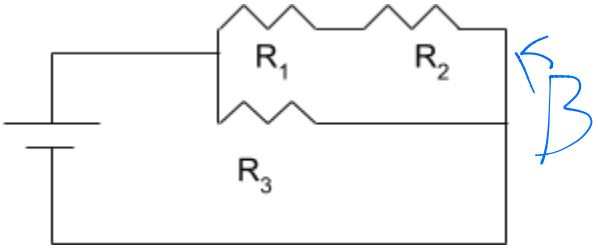
A →



$\frac{1}{R_{23}} = \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{100} + \frac{1}{100} = \frac{2}{200}$

$R_{23} = 50\,\Omega$

Figure A



$R_{123} = R_1 + R_{23} = 150\,\Omega$

Figure B

11. If R_1, R_2 and R_3 are all 100 Ω,
   a. what is the total resistance of the circuit in Figure A? 150Ω
   b. Rank the resistors in term of the amount of current they receive. Be sure to indicate ties. Most: R_1 Tied: R_2, R_3

12 If R_1, R_2 and R_3 are all 100 Ω,
   a. what is the total resistance of the circuit in Figure B? $\frac{1}{200} + \frac{1}{100} = \frac{3}{200} = \frac{1}{R}$ $R = 66.7\,\Omega$
   b. Rank the resistors in term of the amount of current they receive. Be sure to indicate ties. most: R_3, R_1 tied with R_2

13. In a circuit there are five resistors (R_1, R_2, R_3, R_4 and R_5) and 3 different ways to get from the positive terminal of the battery to the negative terminal. The different pathways are listed below. From these options, draw a circuit diagram for the whole circuit.

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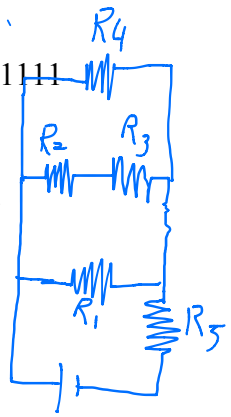

(1) Through R_1, then R_5 and to the negative terminal of the battery.
(2) Through R_2, then R_3, then R_5 and to the negative terminal of the battery.
(3) Through R_4, then R_5 and to the negative terminal of the battery.

14. What is the resistance of n resistors of resistance R arranged in series? nR
15. What is the resistance of n resistors of resistance R arranged in parallel? $\frac{R}{n}$

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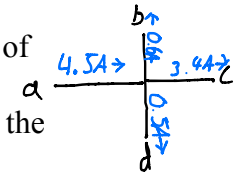
Physics Unit: DC Circuits
Worksheet 4: Combination Circuits

Review:

1. Three 100-Ω resistors are connected in series to a 12 volt battery.
   a. What is the total resistance of the circuit? 300Ω
   b. What current runs out of the battery? $\frac{12}{300} = \frac{4}{100} = 0.04A$
   c. What current runs through each resistor? 0.04A
   d. What is the voltage across each resistor? 4V

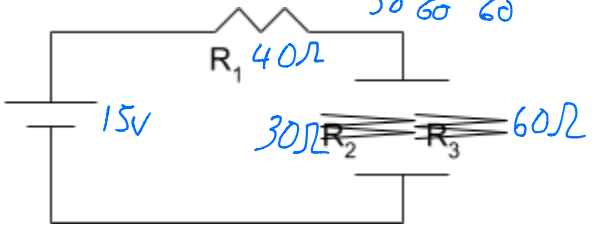
2. Three 100-Ω resistors are connected in parallel to a 12 volt battery.
   a. What is the total resistance of the circuit? $\frac{1}{100}+\frac{1}{100}+\frac{1}{100}=\frac{3}{100}=\frac{1}{R}$ $R=33.3\Omega$
   b. What current runs out of the battery? $\frac{12}{333}=I=0.36A$
   c. What current runs through each resistor? $=0.12A$
   d. What is the voltage across each resistor? 12V

3. Four wires (A, B, C and D) come together in a junction. Wire A carries a current of 4.5 amps towards the wire while wire B carries a current of 6.0 amps away from the junction. If wire C carries a current of 3.4 amps away from the junction then what is the current through wire D? $4.5-0.6-3.4=0.5A$



4. A 12-volt battery is connected to three resistors (R_1, R_2 and R_3) in series. R_1 is 400 Ω and R_2 is 300 Ω. If the current coming out of the battery is 0.01 amps, what is the value of R_3? $V=IR$ $R=\frac{V}{I}=\frac{12}{0.01}$ $R=1200\Omega$ $\Sigma R=1200=400+300+R_3$ $R_3=500\Omega$

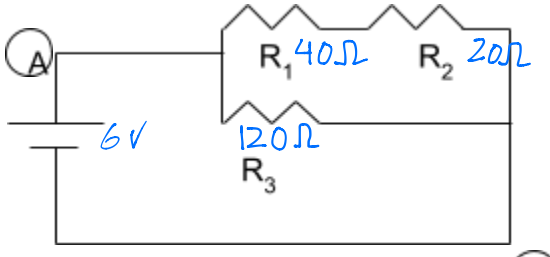
5. In the circuit to the right, the resistances are $R_1 = 40\ \Omega$, $R_2 = 30\ \Omega$ and $R_3 = 60\ \Omega$. The voltage of the battery is 1.5 volts.
   a. What is the net resistance of the circuit? 60Ω
   b. What is the current from the battery? $\frac{15}{60}=\frac{1}{4}=0.25A$
   c. Rank the resistors in terms of the amount of current from the one with the greatest current to the one with the least (including ties). 40Ω, 30Ω, 60Ω



$\frac{1}{30}+\frac{1}{60}=\frac{3}{60}=20\Omega$

$\frac{1}{60}+\frac{1}{120}=\frac{2+1}{120}=\frac{1}{40}$ $R=40\Omega$

6. In the circuit to the right, the resistances are $R_1 = 40\ \Omega$, $R_2 = 20\ \Omega$ and $R_3 = 120\ \Omega$. The voltage of the battery is 6 volts.
   a. What is the net resistance of the circuit? 40Ω
   b. What is the current from the battery? $\frac{6}{40}=6.67A$
   c. Rank the resistors in terms of the amount of current from the one with the greatest current to the one with the least (including ties). R_1, R_2 Tied, then R_3
   d. What is the electric potential at point A? 6V
   e. What is the electric potential at point B? 0V
   f. What is the potential difference across R_3? 6V
   g. What is the voltage across the R_1, R_2 branch of the circuit? 6V



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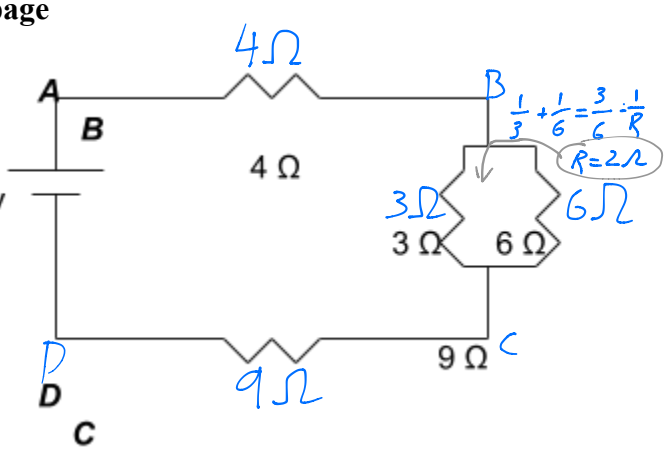
7. Use the circuit to the right to answer the following questions.



a. Find the total resistance of this circuit

b. What current runs out of the battery?

c. What is the potential at points A, B, C and D? $V_A =$ 6 V, $V_B =$ 6-1.6=4.4V, $V_C =$ 4.4-0.8=3.6V $V_D =$ 3.6-3.6=0

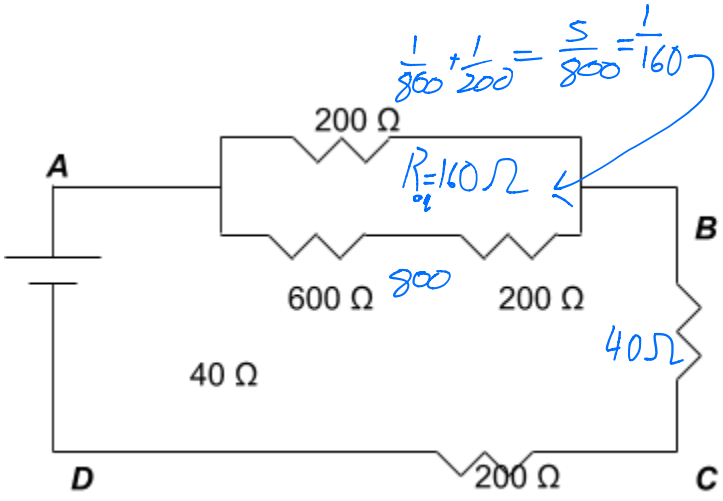
d. Find the voltage across and current through each resistor in this circuit. (You might not do them in this order. I wouldn't.)

$V_{4\Omega} =$ 1.6V $V_{3\Omega} =$ 0.8V $V_{6\Omega} =$ 0.8V $V_{9\Omega} =$ 3.6V

$I_{4\Omega} =$ 0.4 A $I_{3\Omega} =$ 0.267A $I_{6\Omega} =$ 0.133A $I_{9\Omega} =$ 0.4 A

$P_{4\Omega} =$ 0.64W $P_{3\Omega} =$ 0.213W $P_{6\Omega} =$ 0.107W $P_{9\Omega} =$ 1.44W

8. Use the circuit to the right to answer the following questions.



a. Find the total resistance of this circuit.

b. If this circuit draws a current of 0.015 A, what is the voltage of the battery?

c. What is the equivalent resistance between points ***A*** and ***B***?

d. What is the total current running from point ***A*** to ***B***?

e. What is the potential at points A, B, C and D?
$V_A =$ 6 V, $V_B =$ 3+40·0.015=3.6V $V_C =$ 0.015·200=3V, $V_D =$ 0 V

f. What is the potential difference (including a sign) in going from point

A to B?	B to C?	C to D?	D to A?
-2.4V	-0.6V	-3V	+6V

g. What is the current through the 40 Ω resistor?

0.015A

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h. What is the current through the 600 Ω resistor?

$\Delta V =$

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Physics Unit: DC Circuits – Review

1. What is the unit for electrical potential or electrical potential difference?
   a. Coulomb b. Watt c. Ohm d. Volt e. Amp
2. What is the unit for electrical resistance?
   a. Coulomb b. Watt c. Ohm d. Volt e. Amp
3. What is the unit for electrical current?
   a. Coulomb b. Watt c. Ohm d. Volt e. Amp
4. What is the unit for power, electrical or otherwise?
   a. Coulomb b. Watt c. Ohm d. Volt e. Amp
5. How much current will be drawn through a circuit with a resistance of 250 Ω and a potential difference of 5 Volts?

$V=IR \qquad I=\frac{V}{R}=\frac{5}{250}=\frac{1}{50}=0.02\,A$

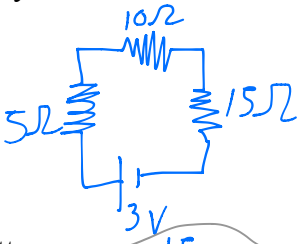
6. A 9 volt battery is connected to a circuit that draws 0.3 A of current from the battery.
   a. At what rate is the battery producing energy (what power is produced by the battery)? $P=IV=0.3\cdot 9=2.7\,W$
   b. What is the resistance of the circuit in the last problem?

$V=IR \quad R=\frac{V}{I}=\frac{9}{0.3}=30\,\Omega$

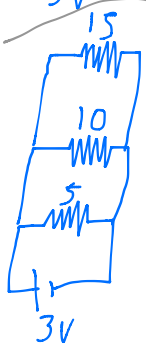
7. A 200 W electrical motor works when connected to a 4 Volt source. What current will it draw? $P=IV \quad I=\frac{P}{V}=\frac{200}{4}=50\,A$
8. Each resistor in a series circuit gets the same current.
9. Each resistor in a parallel circuit gets the same voltage.
10. A circuit has three resistors connected in series to a 12-Volt battery. The current from the battery is 0.002 amps. If R_1 = 1000 Ω and R_2 = 1500 Ω, what is R3?

$V=IR \quad R=\frac{V}{I}=\frac{12}{0.002}=6000\,\Omega=R_1+R_2+R_3=1000+1500+R_3 \quad R_3=3500\,\Omega$

11. What is the total resistance of a circuit with resistors of 2400 Ω, 800 Ω, and 200 Ω wired in parallel? $\frac{1}{R}=\frac{1}{2400}+\frac{1}{800}+\frac{1}{200}=\frac{1+3+12}{2400}=\frac{16}{2400}=\frac{1}{150} \quad R=150$
12. A 5 Ω, a 10 Ω, and a 15 Ω resistor are connected in series to a 3 volt battery.
    a. Draw the circuit.
    b. Find the current through each resistor. $5+10+15 \rightarrow \frac{30}{3}=0.1A$
    c. Find the potential difference across each resistor. 0.5V, 1.0V, 1.5V
    d. Find the power dissipated by each resistor. 0.05, 0.1W, 0.15W
    e. Find the power produced by the battery. 0.3W



13. A 5 Ω, a 10 Ω, and a 15 Ω resistor are connected in parallel to a 3-volt battery.
    a. Draw the circuit.
    b. Find the current through each resistor. $\frac{3}{5}=0.6A, \frac{3}{10}=0.3A, \frac{3}{15}=0.2A$
    c. Find the potential difference across each resistor. 3V
    d. Find the power dissipated by each resistor. 1.8, 0.9, 0.6W
    e. Find the current that flows out of the battery. 1.1A
    f. Find the power produced by the battery. 3.3



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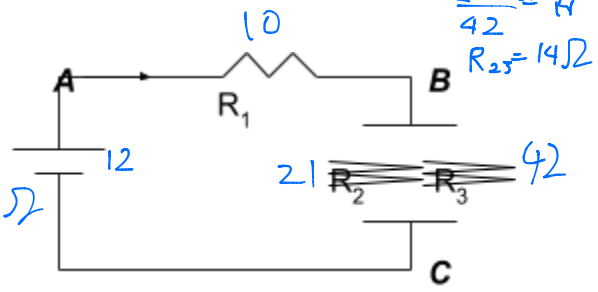
Loop: $\Sigma V = 0$

14. Describe Kirchoff's rules. Junction $I_{in} = I_{out}$

15. For this question, use the circuit shown to the right with the following values: $V_{battery} = 12$ volts, $R_1 = 10\ \Omega$, $R_2 = 21\ \Omega$, $R_3 = 42\ \Omega$



$\frac{1}{21} + \frac{1}{42} = \frac{2+1}{42} = \frac{1}{14}$

$R_{23} = 14\Omega$

a. What is the total resistance of this circuit? $14 + 10 = 24\Omega$

b. What current flows from the battery? $\frac{12}{24} = 0.5A$

c. What is the potential at points A, B and C?

$V_A =$ 12 V, $V_B =$ 12 − 5 = 7 V, $V_C =$ 0 V

d. What is the potential difference (including a sign) in going from point

A to B? −5 V B to C? −7 V C to A? +12 = 0 V ✓

e. Find the voltage across and current through each resistor in this circuit. (You might not do them in this order. I wouldn't.)

$V_1 =$ 5 V $V_2 =$ 7 V $V_3 =$ 7 V

$I_1 =$ 0.5 A $I_2 =$ 0.333 A $I_3 =$ 0.167 A

$P_1 =$ 2.5 W $P_2 =$ 2.33 W $P_3 =$ 1.167 W

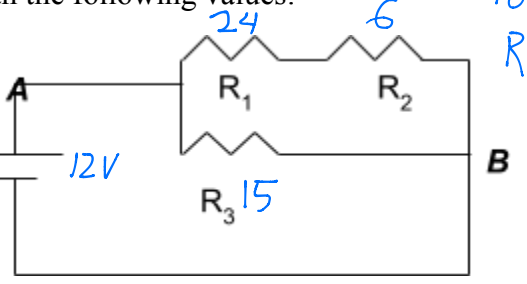
f. At what rate must energy be produced (the power) by the battery?

$P_1 + P_2 + P_3 = I_t \cdot V_t = 6$ W

$\frac{1}{30} + \frac{1}{15} = \frac{1+2}{30} = \frac{1}{10} = \frac{1}{R}$

$R = 10$

16. For this question, use the circuit shown to the right with the following values: $V_{battery} = 12$ volts, $R_1 = 24\ \Omega$, $R_2 = 6\ \Omega$, $R_3 = 15\ \Omega$



a. What is the total resistance of this circuit? 10 Ω

b. What current flows from the battery? $I = \frac{V}{R} = \frac{12}{10} = 1.2A$

c. What is the potential at points A and B?

$V_A =$ 12 V, $V_B =$ 0 V

d. What is the potential difference (including a sign) in going from point

A to B? −12 B to A? 12

e. Find the voltage across and current through each resistor in this circuit. (You might not do them in this order. I wouldn't.)

$V_1 =$ 0.4·24 = 9.6 V $V_2 =$ 0.4·6 = 2.4 V $V_3 =$ 12

$I_1 =$ 1.2 − 0.8 = 0.4 A $I_2 =$ 1.2 − 0.8 = 0.4 A $I_3 = \frac{V}{R} = \frac{12}{15} = 0.8$ A

$P_1 =$ 3.84 W $P_2 =$ 0.96 W $P_3 =$ 9.6 W

f. At what rate must energy be produced (the power) by the battery?

3.84 + 0.96 + 9.6 = 14.4 W

12 · 1.2 =