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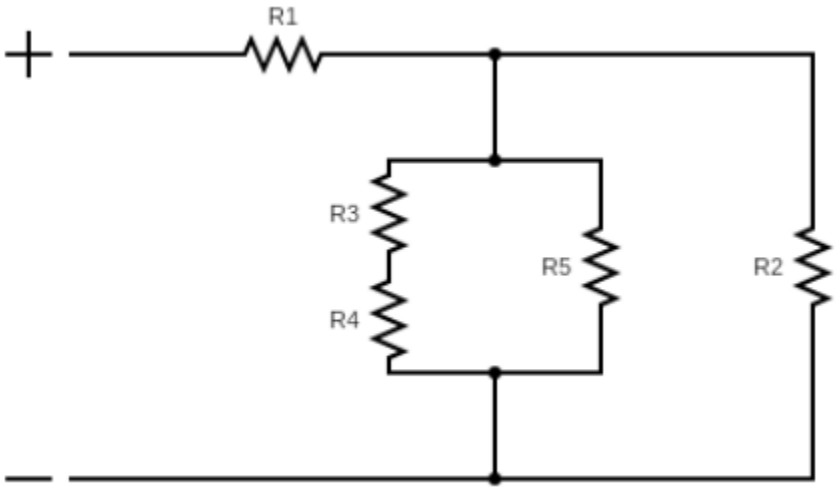
ECE 401

Homework 6

Due 10/21

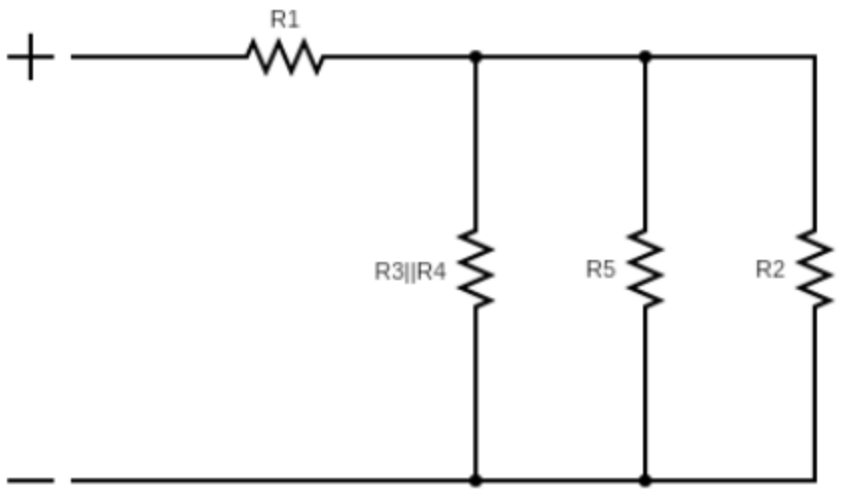
1 Resistive Networks

Using the rules of resistances in Series and in Parallel, find the equivalent resistance, Req, of the following:

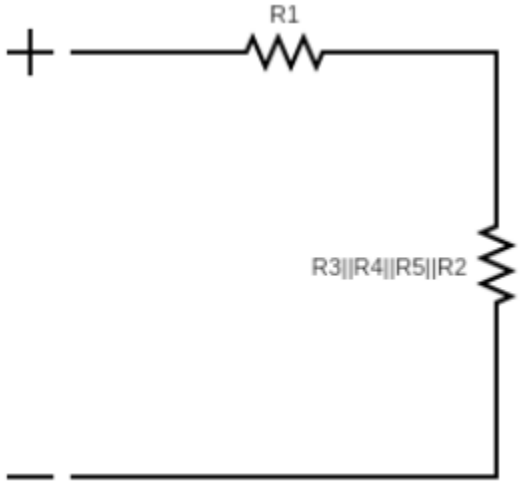


Where R1 = 10 kΩ, R2 = 7.5 kΩ, R3 = 9.1 kΩ, R4 = 3.6 kΩ, and R5 = 5.1 kΩ.

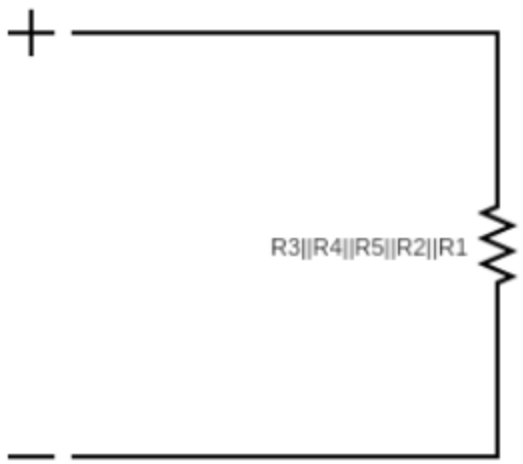
Step 1: Reduce R3 and R4 to form R3||R4
R3 + R4 = R3||R4
9100 + 3600 = 12700
R3||R4 = 12.7kΩ
Equivalent circuit:



Step 2: Reduce R3||R4, R5, and R2 to form R3||R4||R5||R2
1 / ([1 / R3||R4] + [1 / R5] + [1 / R2]) = R3||R4||R5||R2
1 / ([1 / 12700] + [1 / 5100] + [1 / 7500]) =2450
R3||R4||R5||R2 = 2.45kΩ
Equivalent circuit:

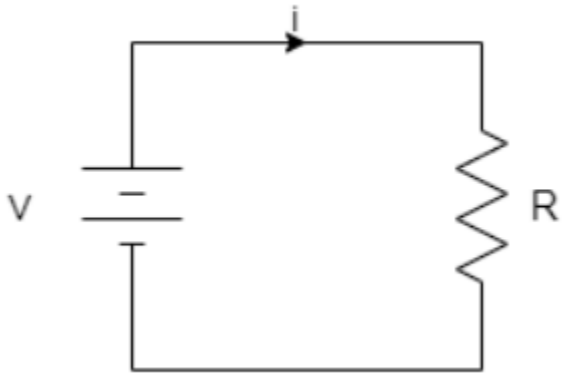


Step 3: Reduce R3||R4||R5||R2 and R1 to form R3||R4||R5||R2||R1
R3||R4||R5||R2 + R1 = R3||R4||R5||R2||R1
2450 + 10000 = 12450
R3||R4||R5||R2||R1 = 12.45kΩ
Equivalent circuit:



2 Ohm's Law

Using Ohm's Law, determine the following from:



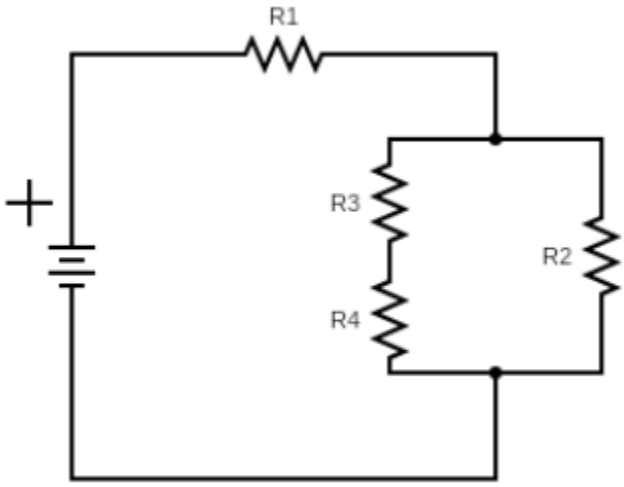
A) The voltage, V, given that resistor has a resistance of R = 1.8 kΩ and the current, I, is 130 mA.
V = I * R
0.13 * 1800 = 234
V = 234V

B) The current, given that R = 2.2 kΩ and V = 12 V
I = V / R
12 / 2200 = 0.005454
I = 5.454 mA

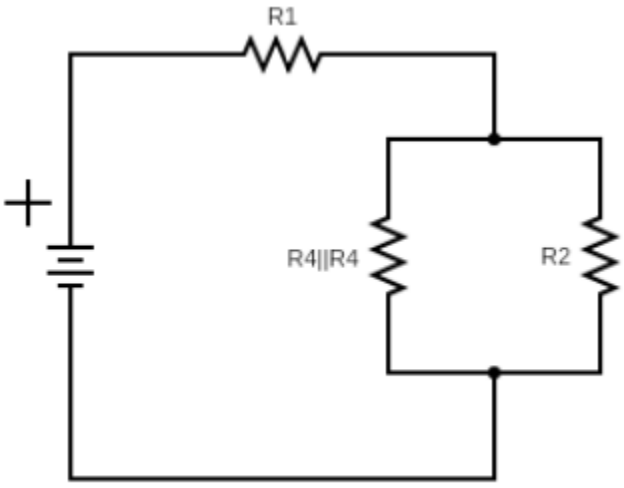
C) The resistance, given that V = 15 V and I = 3 mA.
R = V / I
15 / 0.003 = 5000
R = 5kΩ

3 Circuit Analysis

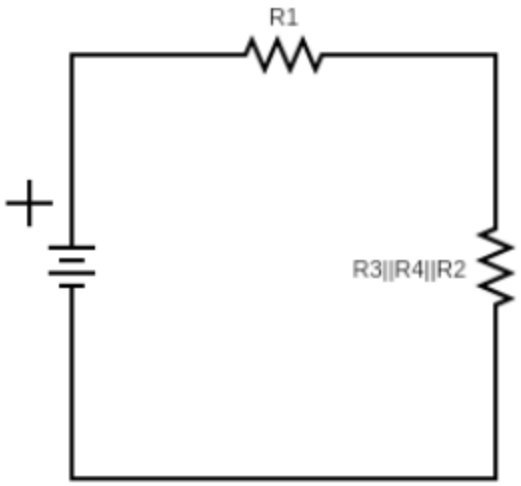
The following circuit has a voltage of 20 V, R1 = 1.8 kΩ, R2 = 9.1 kΩ, R3 = 4.3 kΩ, and R4 = 16 kΩ:



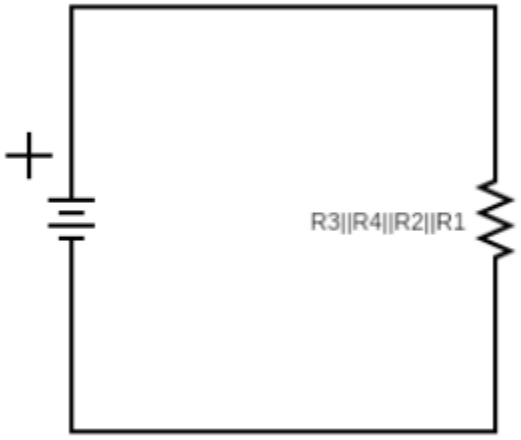
A) Find the current through R2.
Step 1: Reduce R3 and R4 to form R3||R4
R3 + R4 = R3||R4
4300 + 16000 = 20300
R3||R4 = 20.3kΩ
Equivalent circuit:



Step 2: Reduce R3||R4 and R2 to form R3||R4||R2
1 / ([1 / R3||R4] + [1 / R2]) = R3||R4||R2
1 / ([1 / 20300] + [1 / 9100]) = 6283
R3||R4||R2 = 6.283kΩ
Equivalent circuit:



Step 3: Reduce R3||R4||R2 and R1 to form R3||R4||R2||R1
R3||R4||R2 + R1 = R3||R4||R2||R1
6283 + 1800 = 8083
R3||R4||R2||R1 = 8.083kΩ
Equivalent circuit:



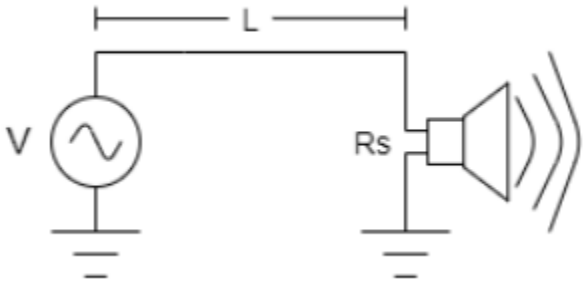
Step 4: Using Ohm's Law, find the total current through the circuit
I = V / R, R = R3||R4||R2||R1
20 / 8083 = 0.00247
I = 2.47mA
Step 5: Using Ohm's Law, find the voltage drop across R1
V = I * R, V = Voltage drop, R = R1
0.00247 * 1800 = 4.446
Voltage drop across R1 = 4.446V = V_{R1}
Step 6: Compare the total voltage to the voltage drop across R1 to find $V_{R3||R4||R2}$
$V - V_{R1} = V_{R3||R4||R2}$
20 – 4.446 = 15.554
$V_{R3||R4||R2} = 15.554$

Step 7: From $V_{R3||R4||R2}$, find both V_{R2} and $V_{R3||R4}$
$V_{R2} = V_{R3||R4} = V_{R3||R4||R2} / 2$
15.554 / 2 = 7.777
$V_{R2} = V_{R3||R4} = 7.777V$
Step 8: Using Ohm's Law, Find the current through R2
I = V / R
7.777 / 9100 = 0.000854
I = 0.854mA, A is solved

B) Find the voltage across R4.
Step 1: Using the information from part A and Ohm's Law, find the current through R3||R4
I = V / R
7.775 / 20300 = 0.000383
I = 0.383mA, $I_{R3||R4} = I_{R3} = I_{R4}$
Step 2: Using Ohm's Law, find the voltage drop across R4
V = I * R
0.000383 * 16000 = 6.128
V_{R4} = 6.128V, B is solved

4 Long Wire to a Speaker

Up until now, it has been assumed that the wire in the circuit acts as a perfect conductor. This means that it has no electrical resistance. In reality, wires do offer a small amount of resistance per unit length. For the circuit below, a speaker is connected to a audio source that produces an equivalent DC voltage of 12 V. The signal then travels through L = 3000 meters of wire to a 6 Ω speaker. Assuming the wire has a resistance per meter of 33.2 Ω/m, find the output power of the speaker.

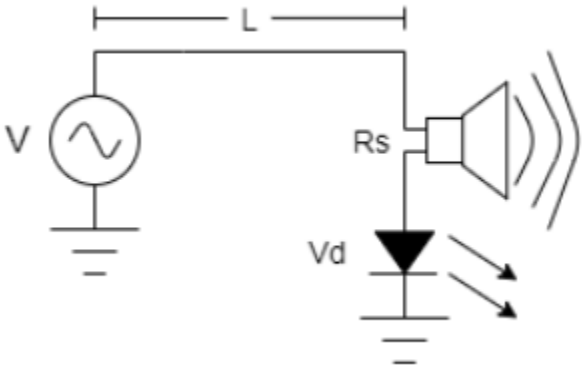


Given:
V_1 = 12V
R_S = 6Ω
L_1 = 3000m
$R_W = 33.2Ω * L_1$
$P = I * V_1$

Step 1: Calculate total Resistance of the wire

$R_W = 33.2\Omega * L_1$
33.2 * 3000 = 99600
$R_W = 99{,}600\Omega$
Step 2: Add R_W and R_S to get R_t
$R_t = R_W + R_S$
99600 + 6 = 99606
$R_t = 99606\Omega$
Step 3: Use Ohm's Law to find the current through the circuit
$I = V_1 / R_t$
12 / 99606 = 0.0001205
I = 120.5µA
Step 4: Use the Generalized Power Law to find the power of the circuit
$P = V_1 * I$
12 * 0.0001205 = 0.001446
P = 1.45mW, solved

To make the speaker more visible, an Light-Emitting Diode (LED) is placed following the speaker. The voltage drop across the LED, Vd, is 0.7 V. What is the new output power of the speaker?



Step 1: Using Ohm's Law, find the new total resistance
$R_{t\,new} = R_{t\,old} + V_d / I$
99606 + 0.7 / 0.0001205 = 105415
$R_{t\,new} = 105{,}415\Omega$
Step 2: Use Ohm's Law to find the current through the circuit
$I = V_1 / R_{t\,new}$
12 / 105415 = 0.0001138
I = 113.8µA
Step 3: Step 4: Use the Generalized Power Law to find the power of the circuit
$P = V_1 * I$
12 * 0.0001138 = 0.001366
P = 1.37mA, solved