Unit 5 : Electricity and Magnetism

Mon Jan 7th,2019

Today's Plan

1. Return Waves and Sound Test

2. Go over year end calendar

3. Intro to Electricity and Magnetism

Electrical Conductivity

proton $+1.602 \times 10^{-19}$ C

Electric Charge One electron has a charge of -1.602×10^{-19} C

C → Coulomb.

A ***conductor*** is a metallic element or compound that has "free" electrons.

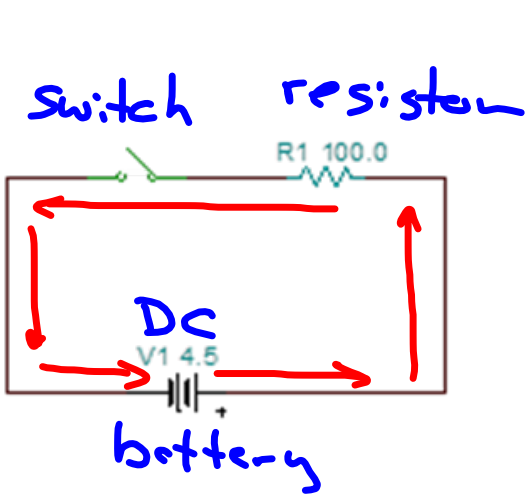
An ***insulator*** is a non-metallic element or compound with "bound" electrons.

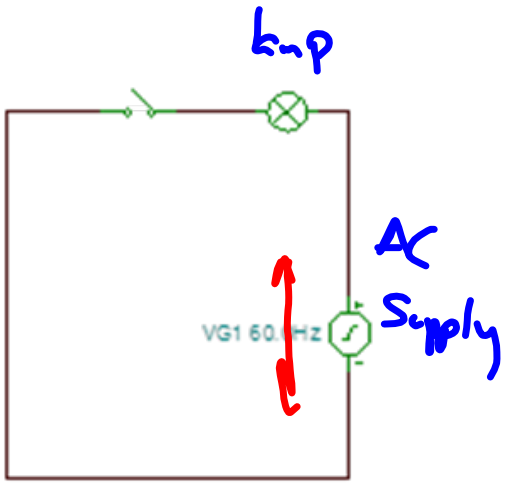
Electric Circuits

An ***Electric Circuit*** is composed of three items

1. Source of current (battery, generator)
2. Load (resistor, lamp, motor)
3. Conductor (wires)

Basic Electrical Circuit Components





1. Electric Current (ch. 12.3)

Electric Current is the flow of charge

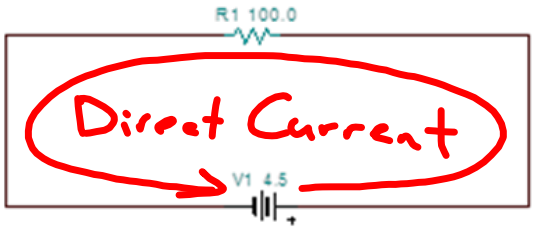
- can be measured as number of electrons that pass a certain point in a given amount of time. or protons

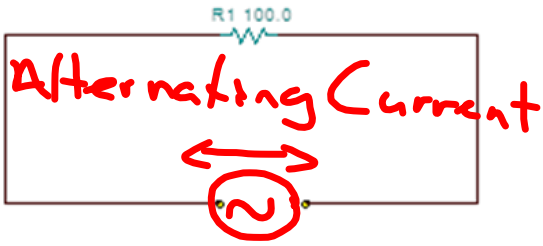
measured as C/s (coulomb/s)

Key Concepts:

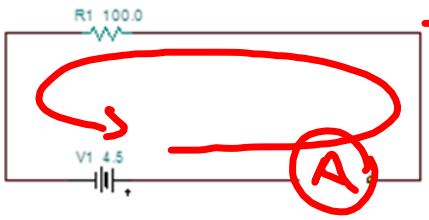
*Conventional Current – flows from positive to negative

Electron Flow - flow from negative to positive

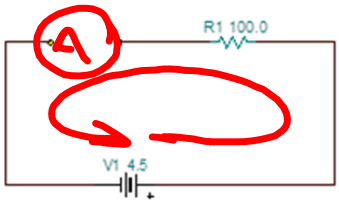




Measuring Electric Current



I=0.045A



(A) ammeter

Symbol I, units amps (A)

ammeter is connected in series.

2. Potential Difference (ch. 12.4)

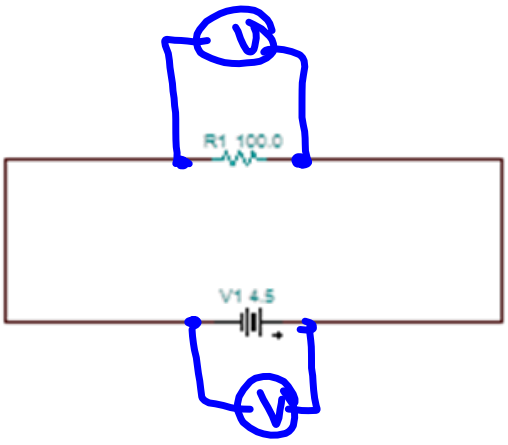
Electric Potential Difference (Voltage) is the amount of Work required per unit charge to move a positive charge from one point to another in the presence of an electric field. measure

J/C

Symbol V, units volts (V)

Measuring Voltage

Voltage measured across a device or source



3. Resistance and Ohm's Law (ch. 12.6)

Electrical resistance is a measure of how much an electric component

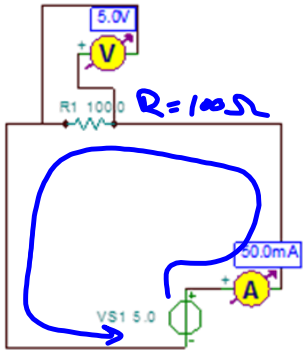
resist the flow of electric charges.

Symbol R, units ohm (Ω)

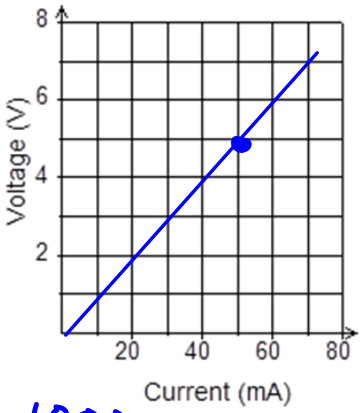
Conductors have a very low R. Insulators have a very high R.

Investigation (using Edison)

V (V)	I (A)
0	0
1	0.010
2	0.020
3	0.030
4	0.040
5	0.050



R = 100Ω



1000 mA = 1A

Ohm's Law

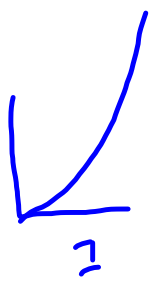
Slope = rise / run = 5V / 0.05A = 100 V/A = Resistance

y = mx + b

$V = IR$ *

Non Ohm's Law Devices

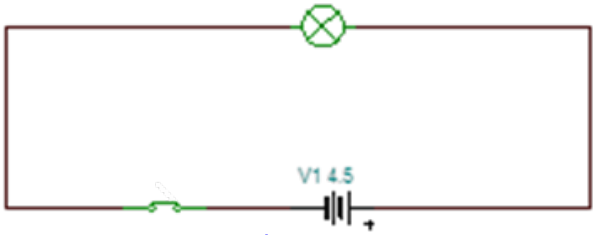
I	V	R = V/I
3	7	2.3
2	3.5	1.8
1	.87	.87



Simple Series Circuit Analysis

Calculate the current through the series circuit with a 4.5V battery and a 180Ω load.

R = 180Ω



V = 4.5 V

$$I = \frac{V}{R} = \frac{4.5V}{180\Omega} = 0.025A$$

or

25 mA

Electrical Power

Recall power = energy consumed or generated per unit time.

$P = \frac{\Delta E}{t}$

units $J/s = Watt$

$V = J/C$

$I = C/s$

$V \times I = \frac{J}{\cancel{C}} \times \frac{\cancel{C}}{s}$

$= \frac{J}{s} = Watt$

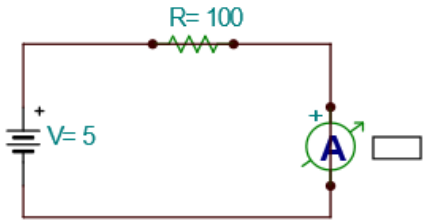
$$P = V \times I$$

Homework : Analyze the following series circuits using Ohm's Law

Calculate the current in the circuit to the right

I = 0.05 A or 50 mA

P = VI = 0.25 W

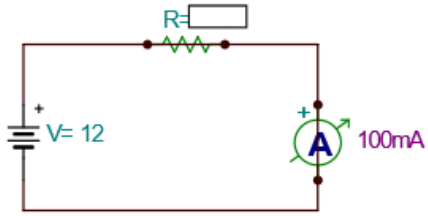


Calculate the required resistance to generate a current of 100mA with a supplied voltage of 12V.

R = 120 Ω

P = 1.2 W

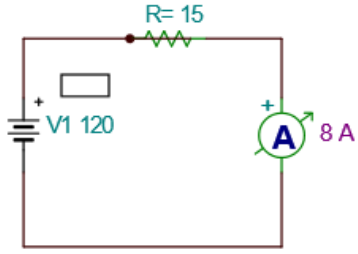
I = 0.100 A



Calculate the voltage required to generate a current of 8A through a load of 15 ohms.

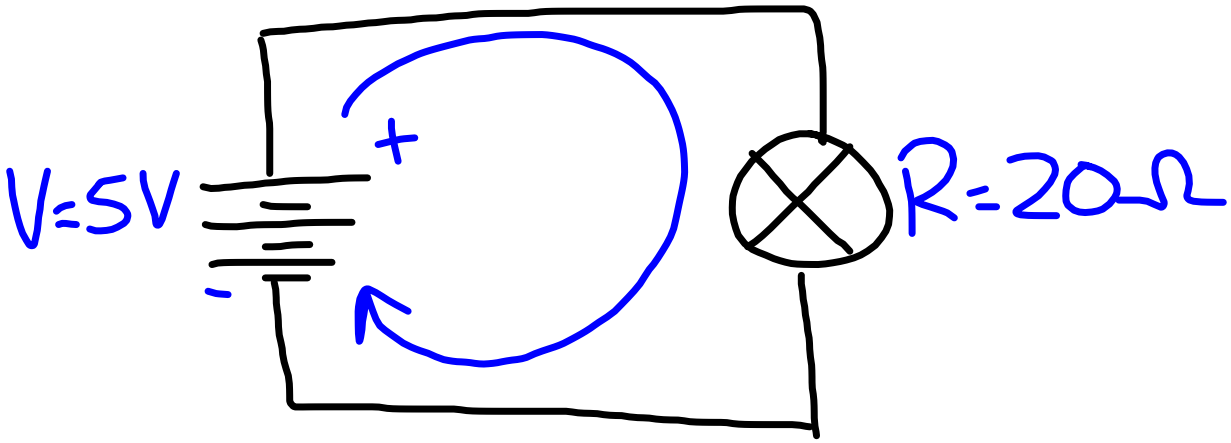
V = 120 V

P = 960 W



h/w calculate power for each circuit.

Practice



Draw the above circuit in your notes.

1. Show the direction of the current.

2. If the lamp is rated for 1 Watt, will it burn out?

$P = V \times I$ $I = 0.25A$

$P = 1.25W$

Jan 9th, 2019

Unit 5 : Electricity and Magnetism - day 3

Today's Plan

1. review - basic electric circuits & power
2. Kirchoff's Current and Voltage Laws
   - parallel vs series analysis
3. Intro to magnetism (time permitting)

Next Day

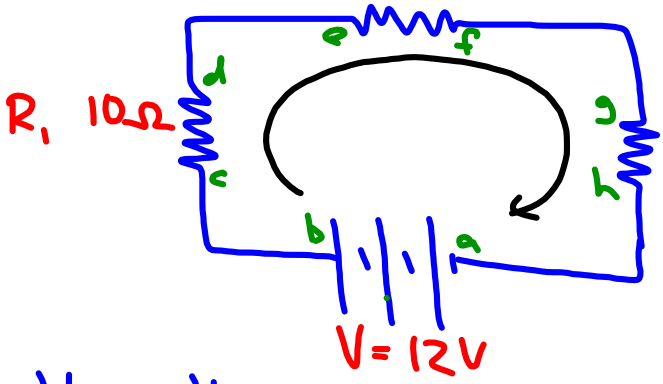
Jan 10th - Edison Circuit Analysis Assignment

Kirchhoff's Voltage Law


Gustav Robert Kirchhoff
(1824-1887)

The algebraic sum of all voltages in a loop must be zero.

1. Series circuit analysis $R_2 = 20\Omega$



R_1 10Ω

$R_3 = 30\Omega$

$I_1 = I_2 = I_3 = I_T$

$V = 12V$

$V_{ab} + V_{cd} + V_{ef} + V_{gh} = 0$

Steps to Solve a series circuit

1. Calculate total resistance

$$R_T = R_1 + R_2 + R_3 = 60\Omega$$

2. Calculate total current

$$I_T = \frac{V_T}{R_T} = \frac{12V}{60\Omega} = 0.20A$$

3. Calculate voltage drop at each resistor.

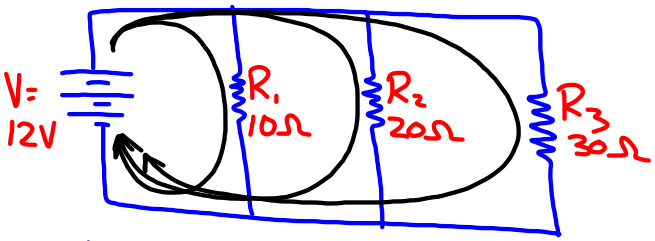
$$V_1 = I_1 R_1 = 0.20A \times 10\Omega = 2V$$
$$V_2 = I_2 R_2 = .2 \times 20 = 4V$$
$$V_3 = I_3 R_3 = .2 \times 30 = 6V$$
$$+ \ 12V$$

4. Calculate ~~total~~ check power.

$$P_T = V_T I_T = 12V \times 0.2A$$
$$= 2.4W$$

Kirchhoff's Voltage Law (cont'd)

2. Parallel circuit analysis



Step 1: calculate the individual voltages.

$V_1 = V_2 = V_3 = 12V$

Step 2: calculate the current thru each resistor.

$I_1 = \frac{V_1}{R_1} = \frac{12V}{10\Omega} = 1.2A$

$I_2 = \frac{V_2}{R_2} = \frac{12V}{20\Omega} = 0.6A$

$I_3 = \frac{V_3}{R_3} = \frac{12V}{30\Omega} = 0.4A$

$I_T = I_1 + I_2 + I_3 = 2.2A$

Step 3: Calculate total (equivalent) resistance.

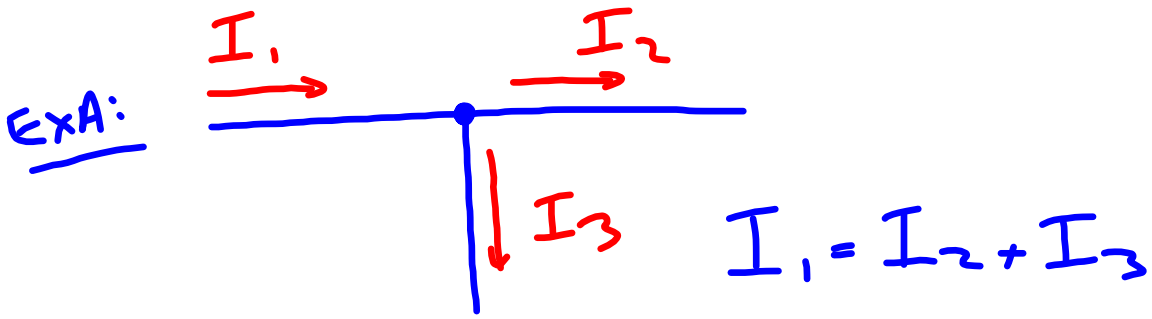
$R_T = \frac{V_T}{I_T} = \frac{12V}{2.2A} = 5.5\Omega$

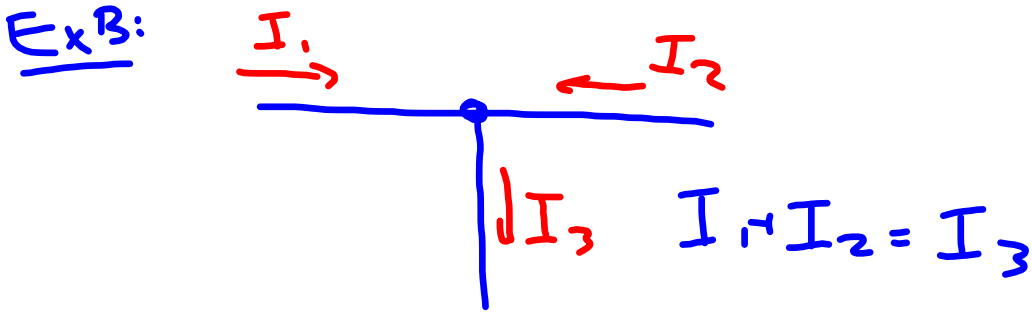
Step 4: Calculate the total power.

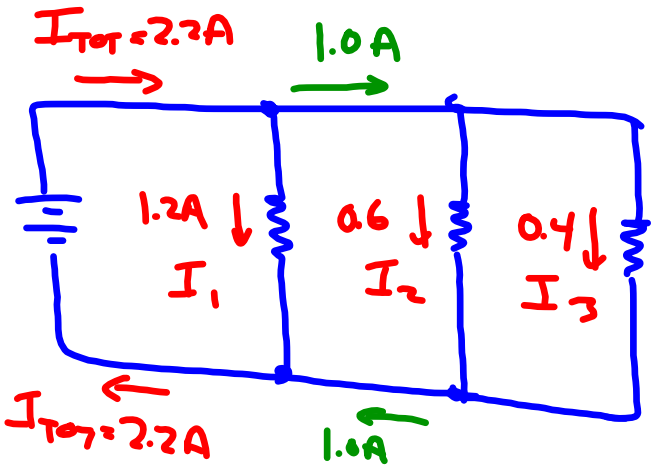
$P_T = V_T I_T = 12V \times 2.2A$
$= 26.4W$

Kirchhoff's Current Law

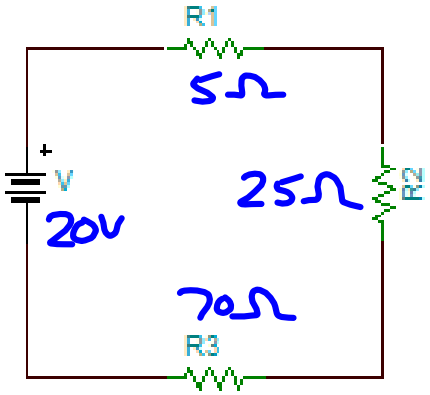
The total current entering a node must equal the current leaving a node.







Simple Series Circuit Analysis



Characterize the circuit. (find all the missing voltages, currents, R_T & Power)

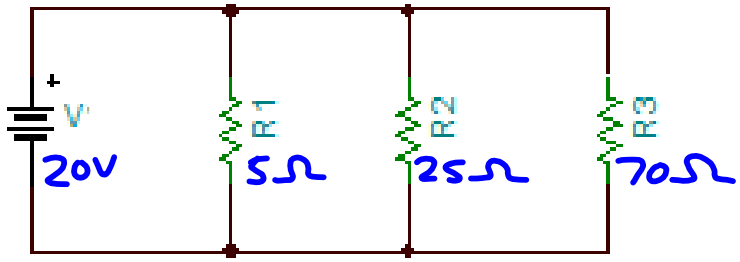
① $R_T = 100\Omega$

② $I_T = 0.2\,A$

③ $V_1 = 1\,V$
$V_2 = 5\,V$
$V_3 = 14\,V$
$\Big\}\ V_T = 20V$ ✓

④ $P_T = V_T I_T = 20V \times 0.2A = 4\,Watts.$

Simple Parallel Circuit Analysis



① $V_1 = V_2 = V_3 = 20V$

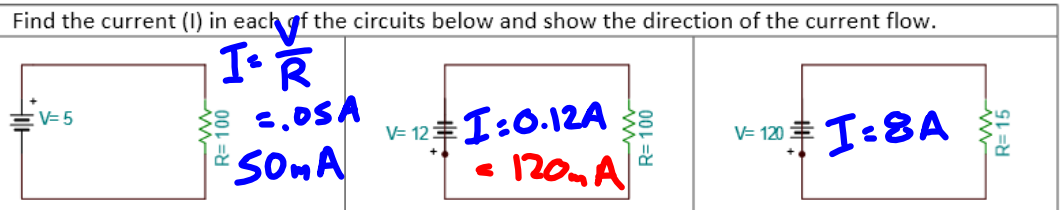
② $I_1 = 4A$
$I_2 = 0.8A$
$I_3 = 0.29A$
$I_T = 5.09A$

③ $R_T = 3.9\Omega$

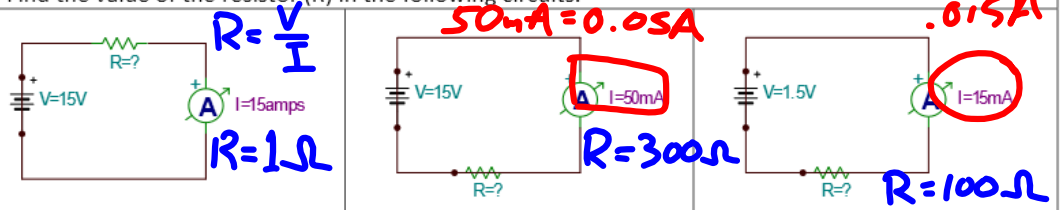
④ $P_T = 102$ Watts.

Ohm's Law

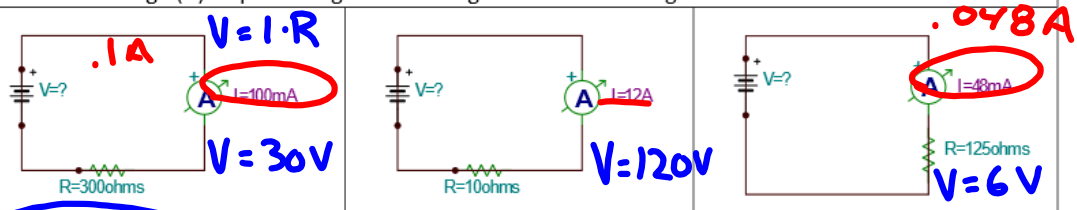
1. Find the current (I) in each of the circuits below and show the direction of the current flow.



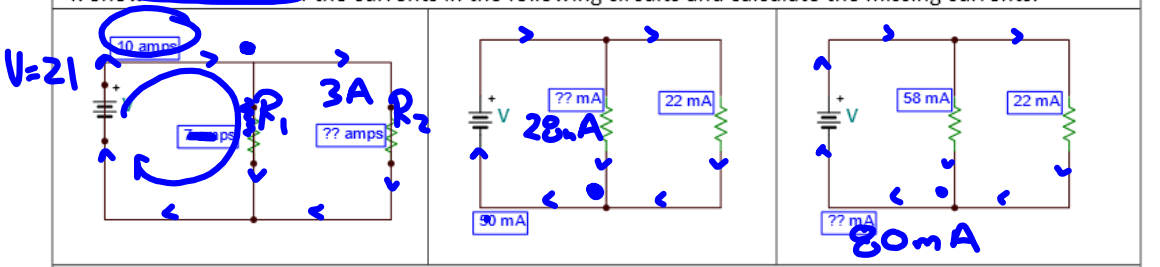
2. Find the value of the resistor (R) in the following circuits.



3. Find the voltage (V) required to generate the given current through the load shown.

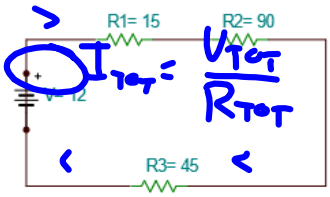


4. Show the direction of the currents in the following circuits and calculate the missing currents.



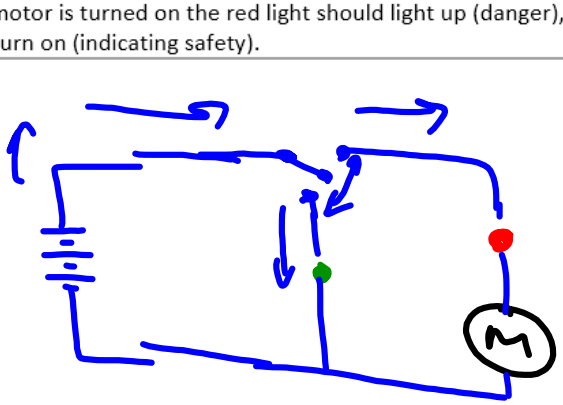
5. In the series circuit below calculate the following values:

a. total equivalent resistance
b. total current through the circuit
c. voltage drop across each resistor
d. total voltage drop across the circuit.

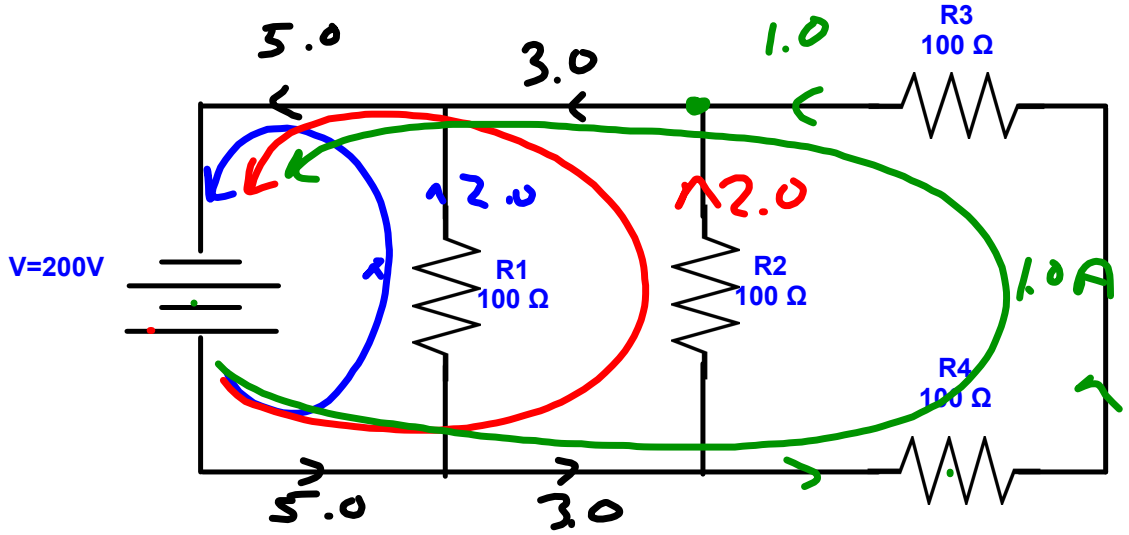


$R_{TOT} = 150\Omega$
$I_{TOT} = 0.08A$
$V_1 = 1.2V$
$V_2 = 7.2V$
$V_3 = 3.6V$
12V

6. Challenge Design Problem:
Design a circuit with a DC power source, one switch, an electric motor, a green light and a red light. When the electric motor is turned on the red light should light up (danger), when the motor is off, the green light should turn on (indicating safety).



Series and Parallel Circuit Analysis



Show the direction of current in the above circuit.
Characterize the circuit
- find voltage and current for each resistor.
- find total current and total (equivalent) resistance for the circuit

Calculate the overall power used in the circuit.

$V_1 = 200V$, $I_1 = 2.0A$

$V_2 = 200V$, $I_2 = 2.0A$

$V_3 = V_4 = 100V$, $I_4 = I_3 = 1.0A$

$5.0A$

$$R_T = \frac{V_T}{I_T} = 40\Omega$$

$$P = V_T I_T = 1000W$$