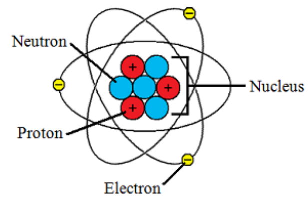
<u>Electric Circuits Notes</u>

1 – Introduction to Circuits Electricity

A) CHARGE [Mr.Cheung can I charge my phone?]



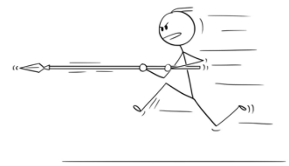


Figure 1: Charge!!!!

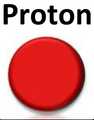
Fundamental particles like ____________, ___________ and _____________ make up in our universe. These particles have different properties like size, mass and charge.

Charge is a fundamental property of matter and it is measured in ________________. Name after French Physicists Charles-Augustin de Coulomb [1736-1806 Figure 2]

*Figure 2: Charles de Coulomb - Your old friend $F_f = \mu F_N$ was my work too. You are welcome ^__^*

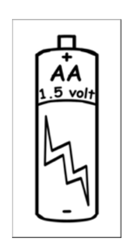
Did you my name is craved into the Eiffel Tower? Ask Mr.Cheung to show you a picture~

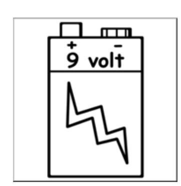
> Atlas: But… but…. daddy what is a charge?
>
> Mr. Cheung: No one can tell you what charge really is, the only rules scientists have discovered so far…..
>
> 1. There are two types of charges (_____________ and ______________) and…
> 2. Charges can interact with each other (via Electric Force)
>   a. Opposite charges _________ each other
>   b. Like charges _________

Particle	**Proton** 	**Neutron** 	**Electron**
Symbol			
Mass			
Charge			

B) ELECTRONS AND ELECTRIC CIRCUIT

Have you ever wonder how energy is delivered to your electronic devices (ie. your TV set and cellphones etc.)? Energy can come from the AC outlet or it be stored in portable storage device like a battery, but nothing is going to happen if you hold up a battery in the air. For energy to flow into your devices, you must provide a ______________/connection between the ____________________ (the AC outlet) and the _______ (ie, your PS4); on top of that you will also need _____________________ (~~uber eats?~~ → electrons)





C) Voltage, Current, resistance and Ohm's Law [let the great pizza analogy begin! Brought to you by Mr. Cheung]

Voltage (Potential Difference) is the change in potential energy per unit charge. It is the amount of energy carried by 1 Coulomb of electrons

V:
E:
Q:

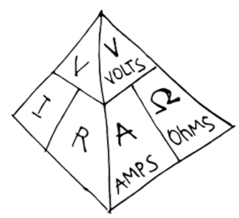

Current is the rate of flow of charge (electron) through the cross-sectional area of a conductor (_______).

I:
Q:
t:

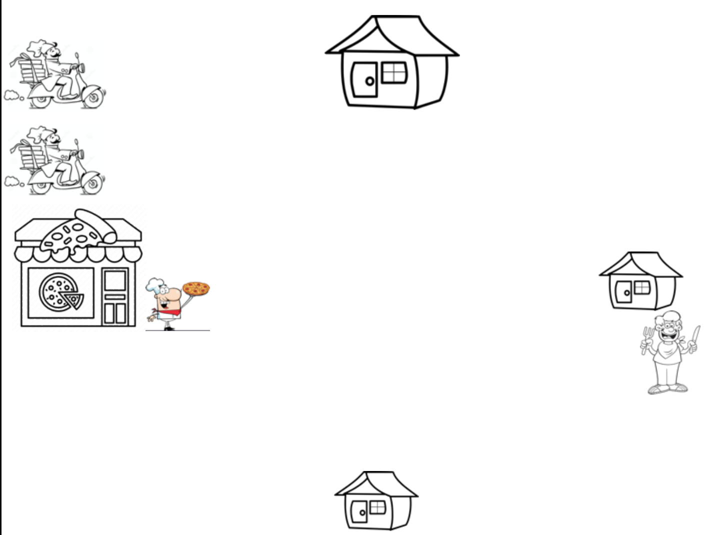

Resistance is a property of material and it is measured in ______________. Some materials have ________ resistance and they are good _________________ (ex, metals); they allow electrons to flow __________. Other materials (ex, wood/plastic/air) have ________ resistance value and they are bad ______________; electrons have a harder time (_____________________) traveling through them.

Ohm's Law: The ratio between the voltage and the current through a conductor (load, resistor) is a constant and represents the resistance of the material.

V: Voltage (___)
I: Current (___)
R: Resistance (___)



<u>Mr.Cheung's Pizza model of Circuity</u>

Series (basic)	Parallel (more complex)
	

D) POWER [Go Go Power Ranger~ sorry I had to… haha]

Recall that power is……..

Electric Power is the rate at which energy is transferred

From the definition of power and Ohm's Law we can derive some formulae to describe **electric power**

Example: An electric fan has a resistance of 12 Ω and requires 0.75 A of current to function properly. What voltage is required to operate the fan?

Example: An electric heater emits 100 W when connected to a 120 V power line. What is the resistance in the heater?

Example: When a 12 V car battery powers a single 30 W headlight, how many electrons pass through it in one minute?

E) DIRECTION OF CURRENT [what do you call a misunderstanding that is never fixed? A convention…]

The direction of current can be considered in two ways:

1) Electron Flow: The direction that the electrons actually move. The electrons go from the __________ to the _____________ terminal.

2) Conventional Current: Flow of positive charge. Positive charges flow from the ____________ to the ____________ terminal.

Figure 3: I am on the US $100 Bill~~

In 1752, prior to electricity being identified with the electron, Ben Franklin chose a convention regarding the direction of current flow. Franklin assumed that ___________ charge carriers flowed from positive to negative terminals. We now know this is incorrect. In metals, the charge carrier is the __________ whose charge is ____________ by definition. As a result, most people still prefer using the direction of the conventional current.

In this class, unless otherwise stated, we will always use ____!!!

F) CIRCUIT SYMBOLS (SCHEMATIC)

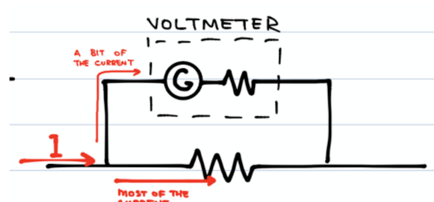
CELL	BATTERY	WIRE	JUNCTION	RESISTOR

BULB	SWITCH (OPEN)	SWITCH (CLOSED)	VOLTMETER	AMMETER

We can measure the voltage in a circuit using a ___________________ and the current in a circuit using a ______________________. But we need to connect these two devices in different ways.

Voltmeter:

- must be connected in ________________________. This is because a voltmeter measures the voltage drop ______________ a device and it has very high _____________.
- Most of the current passes through the ___________ with only a small percentage passing through the ___________ so we won't waste energy.
- "we are trying to measure the ___________ carried by the electrons ___________ and ___________ they go through a power source or a load."



Ammeter:

- An ammeter must be connected in _________________________. This is because an ammeter measures the current ________________ a circuit and it has very low resistance.
- Ammeter is trying to count the ____________ of electrons (in Coulombs) going through the conductor wire per second. You have to stand in the ___________ in order to count the people ^___^

Circuit Worksheet 5.1: Current/Voltage/Ohm's Law

1) A current of 3.60 A flows for 15.3 s through a conductor. Calculate the number of electrons that pass through a point in the conductor in this time.

(3.44×10^{20})

2) How long would it take 2.0×10^{20} electrons to pass through a point in a conductor if the current was 10.0 A?

(3.2 s)

3) Calculate the current if a charge of 5.60 C passes through a point in a conductor in 15.4 s.

(0.364 A)

4) What is the potential difference across a conductor to produce a current of 8.00 A if there is a resistance in the conductor of 12.0 Ω?

(96 V)

5) What is the heat produced in a conductor in 25.0 s if there is a current of 11.0 A and a resistance of 7.20 Ω?

(21800 J)

6) 150 J of heat are produced in a conductor in 5.50 s. If the current through the conductor is 10.0 A, what is the resistance of the conductor?

(0.273 Ω)

7) What is the current through a 400 W electric appliance when it is connected to a 120 V power line?

(3.33 A)

8) a. When an electric appliance is connected to a 120 V power line, there is a current through the appliance of 18.3 A. What is its resistance?

(6.56 Ω)

b. What is the average amount of energy given to each electron by the power line?

$(1.92 \times 10^{-17}$ J)

9) a. What potential difference is required across an electrical appliance to produce a current of 20.0 A when there is a resistance of 6.00 Ω?

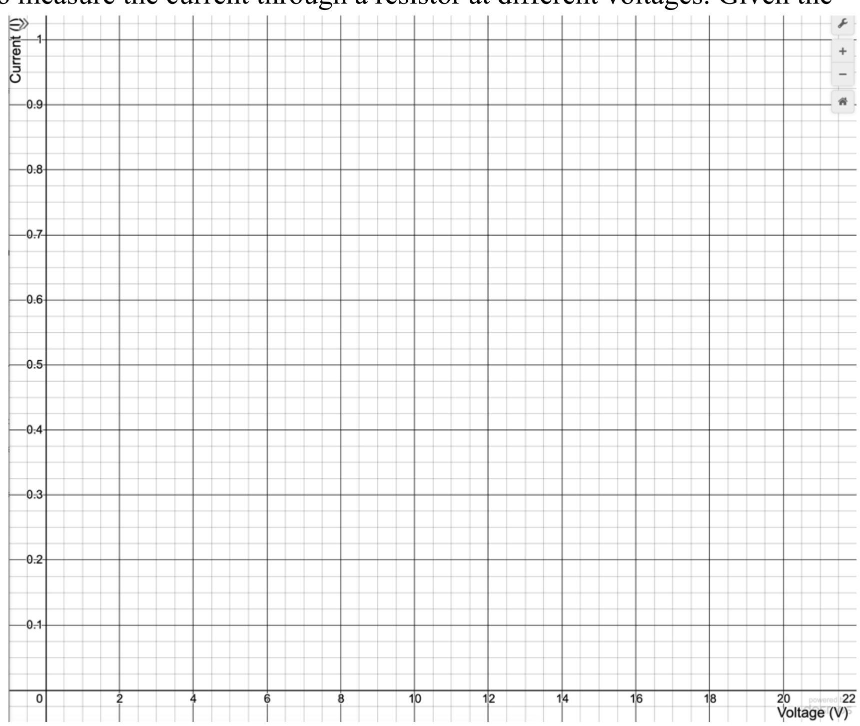
(120 V)

b. How many electrons pass through the appliance every minute?

(7.5×10^{21})

10) A student designed an experiment in order to measure the current through a resistor at different voltages. Given the following data:

Voltage (V)	Current (I)
3.0	0.15
6.0	0.30
9.0	0.45
12.0	0.50
15.0	0.75



a) Draw a graph showing the relationship between current and voltage (V vs. I)

b) Using the graph, what is the resistance of the resistor?

(20.0 +/- 0.5 Ω)

Electric Circuits Notes

2 – Basic Circuit

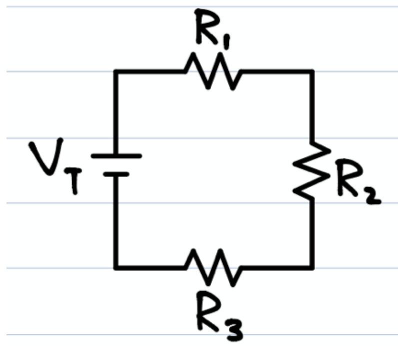
A) SERIES AND PARALLEL CIRCUIT

Series: _______ path for the electrons

$I_T =$

$V_T =$

$R_T =$

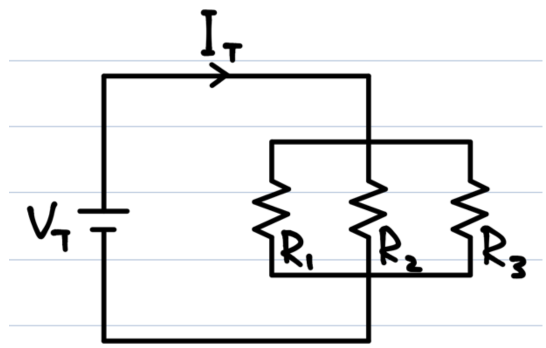


Parallel: more than one path for the electrons

$I_T =$

$V_T =$

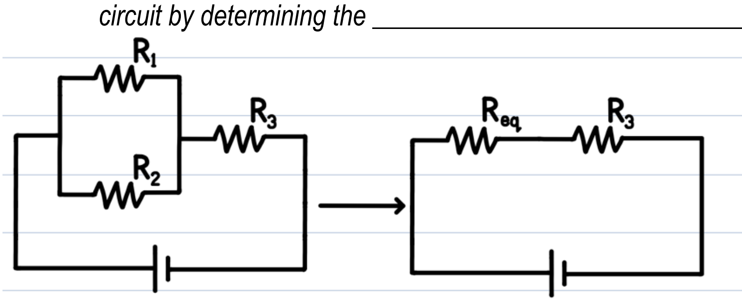
$\frac{1}{R_T} =$



"Adding more paths always ___________ total resistance and ___________ current!!"

B) SOLVING BASIC CIRCUIT PROBLEMS

1. *Draw a circuit diagram if not provided*
2. *Next to each resistor, indicate ____, ____ and ____*
   Next to the battery, indicate V_T, I_T and R_T
3. *Apply Series and Parallel Rules appropriately. For each resistor/battery, when two of V, I and R are known, use _______________________ to determine the third*
4. *For circuit with resistors connected in both series and parallel. You may need to transform the combination circuit into a series circuit by determining the ___________________________ of the parallel branches*

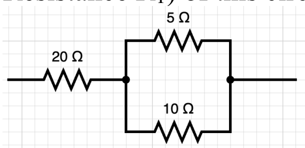


$I_{eq} =$

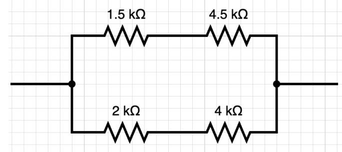
$V_{eq} =$

$\frac{1}{R_{eq}} =$

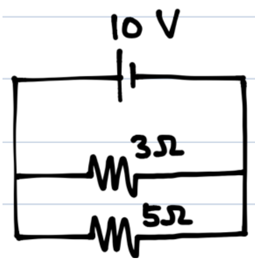
Example 1: What is the equivalent resistance (Total Resistance R_T) of this circuit?



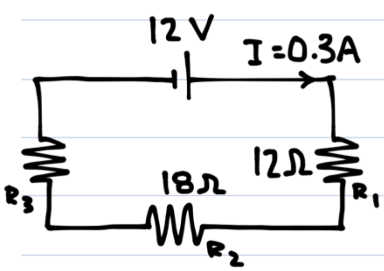
Example 2: What is the equivalent resistance (Total Resistance R_T) of this circuit?



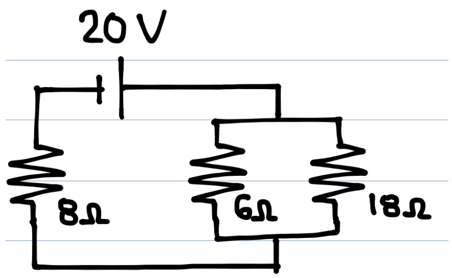
Example 3: Determine the current through the 5Ω Resistor



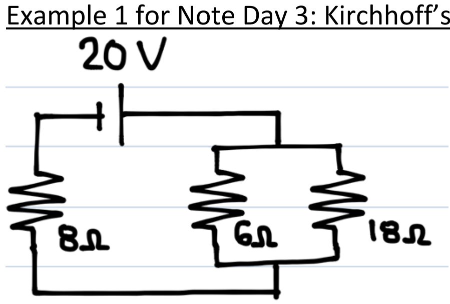
Example 4: Determine the resistance of R_3



Example 5: Determine the current through each resistor.



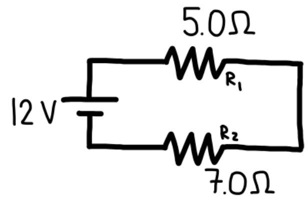
Example 1 for Note Day 3: Kirchhoff's Law: Determine the current through each resistor



<u>Circuit Worksheet 5.2 - Series and Parallel Circuits</u>

For each circuit, determine the voltage, current and resistance through each resistor and the total voltage, current and resistance of the circuit.

1.



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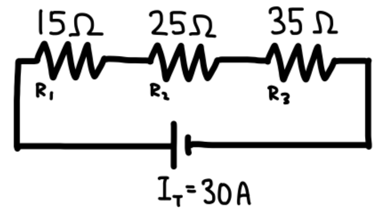

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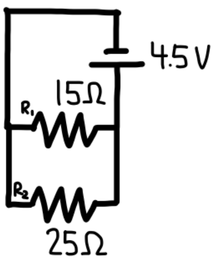

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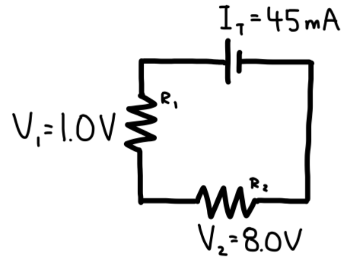

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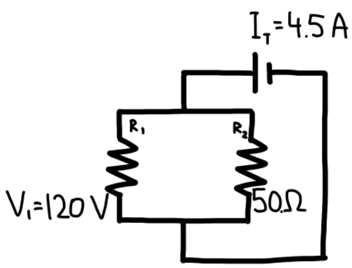

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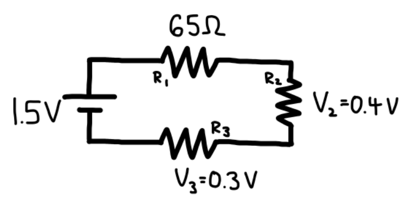
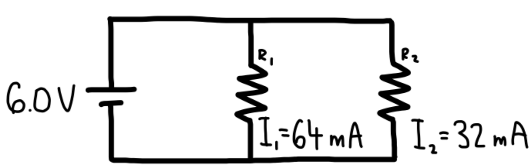
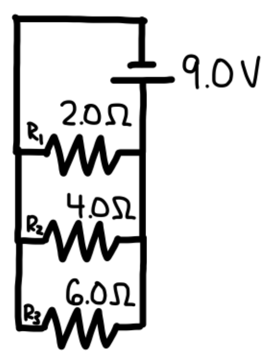


7.



8.



Answers:

Q1) $R_T = 12\,\Omega;\ I_T = I_1 = I_2 = 1.0\,A;\ V_1 = 5.0\,V;\ V_2 = 7.0\,V$

Q2) $R_T = 75\,\Omega;\ I_T = I_1 = I_2 = I_3 = 30\,A;\ V_T = 2250\,V;\ V_1 = 450\,V;\ V_2 = 750\,V;\ V_3 = 1050\,V$

Q3) $V_T = V_1 = V_2 = 4.5\,V;\ I_1 = 0.30\,A;\ I_2 = 0.18\,A;\ I_T = 0.48\,A;\ R_T = 9.375\,\Omega;$

Q4) $I_T = I_1 = I_2 = 45\,mA$ or $0.045\,A;\ R_1 = 22.2\,\Omega;\ R_2 = 177.8\,\Omega;\ V_T = 9.0\,V;\ R_T = 200\,\Omega$

Q5) $V_T = 120\,V;\ I_2 = 2.4\,A;\ I_1 = 2.1\,A;\ R_T = 26.7\,\Omega;\ R_1 = 57.1\,\Omega$

Q6) $V_1 = 0.8\,V;\ I_1 = 12.3\,mA$ or $0.0123\,A;\ R_T = 121.9\,\Omega;\ R_2 = 32.5\,\Omega;\ R_3 = 24.4\,\Omega$

Q7) $V_1 = V_2 = 6.0\,V;\ I_1 = 96\,mA$ or $0.096\,A;\ R_T = 62.5\,\Omega;\ R_1 = 93.75\,\Omega;\ R_2 = 187.5\,\Omega$

Q8) $V_T = V_1 = V_2 = V_3 = 9.0\,V;\ I_1 = 4.5\,A;\ I_2 = 2.25\,A;\ I_3 = 1.5\,A;\ I_T = 8.25\,A;\ R_T = 1.09\,\Omega$

Electric Circuits Notes

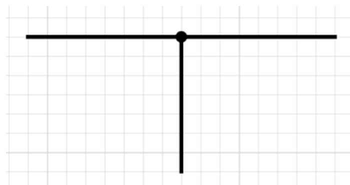
3 – Kirchhoff's Laws

A) Kirchhoff's Current Law: AKA ________________________

"The sum of current going into a junction is ___________________________

____"

For any junctions:



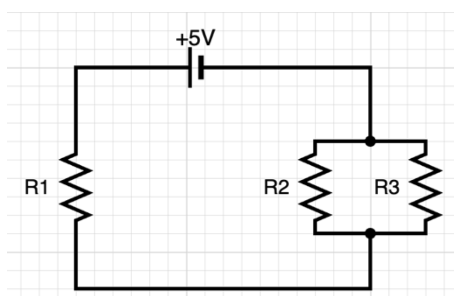
Cheung's Current Law: Enjoy your meal but don't eat the person who delivers the food!!

B) Kirchhoff's Voltage Law: AKA ________________________

"For any closed loop, the sum of voltage gain is _________________________

____"

For any loops in the circuit:

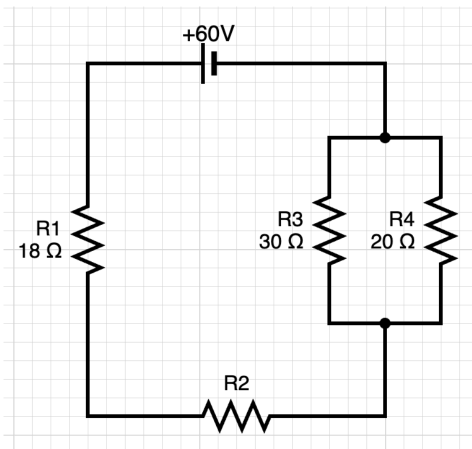


Cheung's Voltage Law: I give you 10 pizzas, you deliver 10 pizzas!!

C) Solving Circuits with Kirchhoff's Laws – an alternate method, useful for more complicated circuits

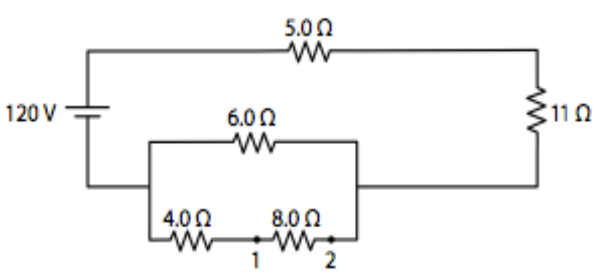
1. **Draw a circuit diagram if not provided**
2. **Next to each resistor, indicate V, I and R**
3. **Next to the battery, indicate V_T, I_T and R_T**
4. **Indicate the direction of current of each part of the circuit**
5. **Apply the Current Law to each _________. Try to find a junction with only one unknown ________.**
6. **Apply the Voltage Law to each _________. Try to find a loop with only one unknown ___________.**
7. **You might need to calculate __________________________________ of the parallel branches to simplify the question.**
8. **Use Ohm's Law $V = IR$ or Power formula $P = IV = I^2R = \frac{V^2}{R}$ to help you at any time ^____^**

Example 2: What is the value of V_1, V_2 and R_2 in the circuit



V1 = 9V, V2 = 45V, R2 = 90 Ω

Example 3: a) What is the voltage across the 8.0 Ω resistor
b) How much power is dissipated in the 5.0 Ω resistor



a. 16 V b. 180 W

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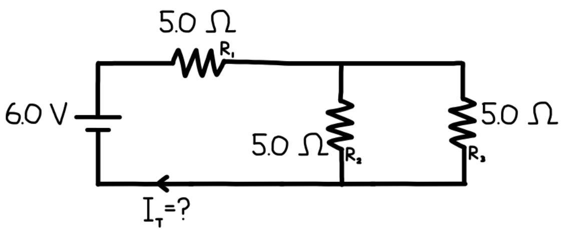
Name:

Block:

WS 3: Combination Circuits

For each circuit, determine unknown quantity indicated on the diagram.

1.



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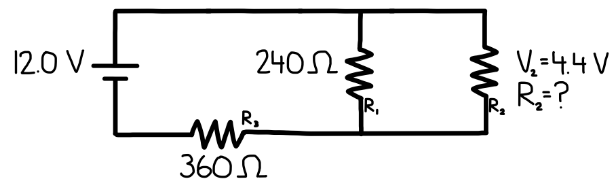

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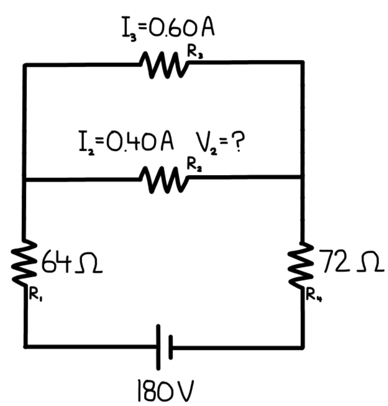

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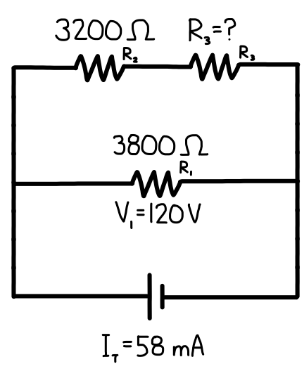

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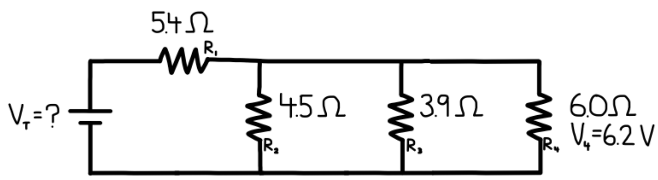
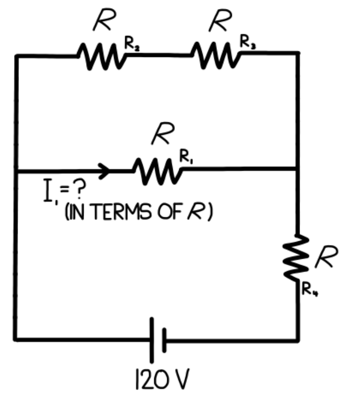
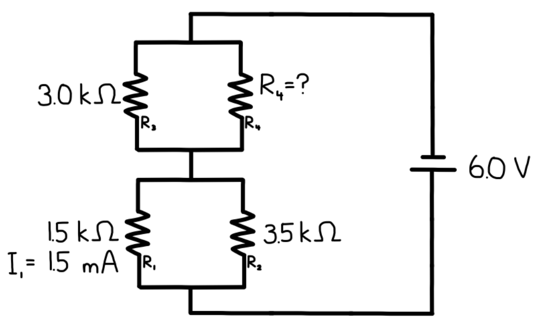

5.4 Ω
R1
V_T = ?
4.5 Ω
R2
3.9 Ω
R3
6.0 Ω
R4
V4 = 6.2 V

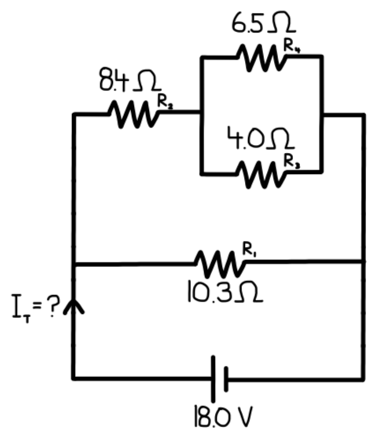
6.


R
R2
R
R3
R
R1
I1 = ?
(IN TERMS OF R)
R
R4
12.0 V

7.


3.0 kΩ
R3
R4 = ?
R4
6.0 V
1.5 kΩ
I1 = 1.5 mA
R1
3.5 kΩ
R2

8.


6.5 Ω
R4
8.4 Ω
R2
4.0 Ω
R3
R1
10.3 Ω
I_T = ?
18.0 V

Electric Circuits Notes

4 – Electromotive Force

We know that a battery is a source of potential difference (_______________) or electric energy. When not connected to a circuit there is a potential difference between the terminals.

This voltage is also known as…

Despite the name, this is a ____________________ not a _________________.
This dates back to a time when we thought that the two were equivalent.

For example a car battery has an EMF of ___________ and lithium battery has an EMF of ____________.

However, as soon as a battery is connected to a circuit and current flows through it the potential difference across the terminals is always…

This is due to the fact that every battery has…

Because of this ________________ _________________ the terminal voltage is always ________________ than the EMF of the battery.

Where:

Note: Ir =

Note: If the battery is not connected to a circuit…

Consider the following diagram showing a circuit with an external resistance, ________, internal resistance _______ and EMF ________.

When a battery goes dead it is because…

Example:
If a 12.0 V battery has an internal resistance of 0.220 ohms, what is the terminal voltage of the battery when a current of 3.00 A flows through the battery?

When a rechargeable battery is being charged an external voltage is applied to the battery. In order to force electrons backwards into the battery the external voltage must be…

In fact the external voltage must be:

Example:
A 12.0 V car battery is being charged by an alternator that can supply 15 V. If the internal resistance of the battery is 1.3 ohms, what is the current through the battery?

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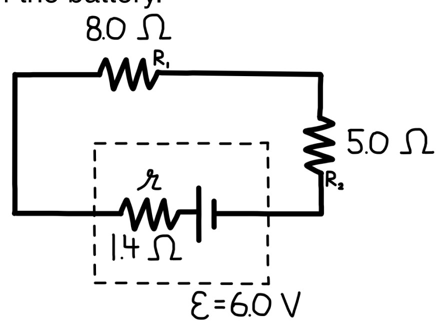
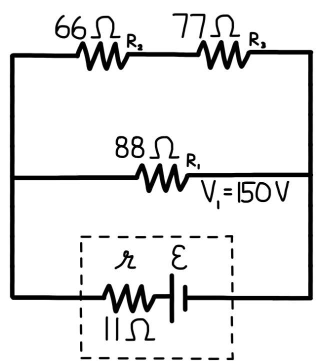
Terminal Voltage and More

Block:

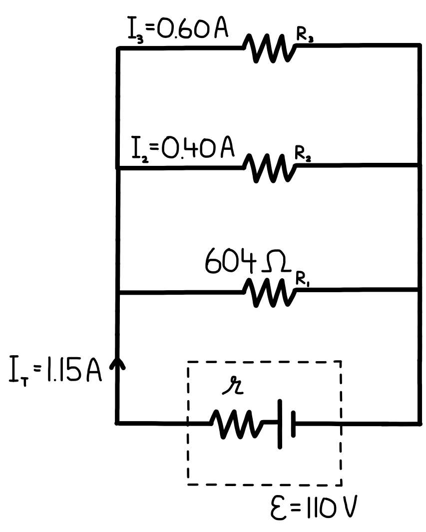
1. Determine the terminal voltage of the battery.



2. Determine the emf of the cell.

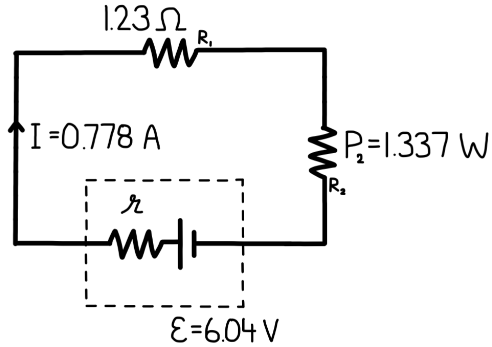


3. A battery with an internal resistance is connected to three resistors as shown.

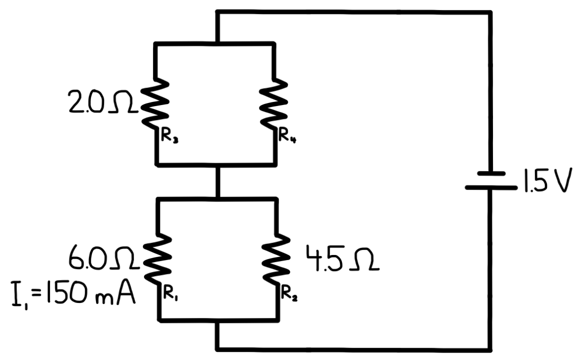


a) Determine internal resistance.
b) What power is dissipated in the battery's internal resistance?

4. Determine the internal resistance of the battery.



5. An ideal battery is connected to four resisters as shown.



a) How much charge flows through R_4 in 1 hour?
b) What power is dissipated by R_4?
c) How much energy is dissipated by R_4 in 1 hour?

6. When a power supply whose emf is 12.0 V is connect to a resistor, it delivers 9.0 A of current. When the same supply is connected to two identical resistors in series, the current from the supply is 5.0 A. Determine the internal resistance of the supply.