

ECE 109 - THE VERY BASICS - INVESTIGATION 2

VOLTAGE DROPS

SUMMER 2007

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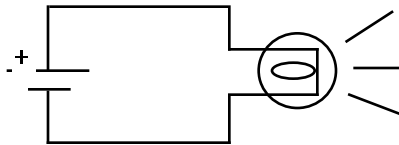
To do "well" on this investigation you must not only get the right answers but must also do neat, complete and concise writeups that make obvious what each problem is, how you're solving the problem and what your answer is. You also need to include drawings of all circuits as well as appropriate graphs and tables.

From the last Investigation we know that equivalent positive charges in a flashlight circuit flow from the battery to the light bulb and then back to the battery. The objective of this Investigation is to show how we keep track of the energy these equivalent positive charges receive from the battery and then deliver to the bulb to make it light. Be sure to take a look at the **Computer Demos** on Voltage Reference Directions.

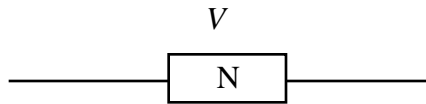
1. Let us begin with a review problem. Draw pictures showing the direction equivalent positive charge is flowing in the following wire



- a. When $I > 0$
 - b. When $I < 0$
2. As we said in the introduction flashlights produce light from the energy they receive from the equivalent positive charges flowing through them - energy the equivalent positive charges receive from the battery. Suppose in particular that every 1.5 coulombs of equivalent positive charge flowing through the flashlight circuit as follows



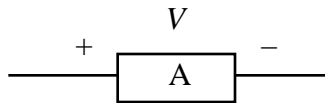
- delivers 4.5 joules of energy to the filament of the bulb
- a. How many joules of energy will 2.5 coulombs of equivalent positive charge transfer to the bulb
 - b. How many joules of energy will 3.2 coulombs of equivalent positive charge transfer to the bulb
3. Calculations like those in Problem (2) are easy once we know the number of joules/coulomb the equivalent positive charges transfer to the bulb as they flow through it
 - a. What is the number of joules/coulomb transferred to the bulb in Problem (2) by the equivalent positive charge flowing through it
 - b. Make use of your result in part (a) to determine how many joules of energy will be transferred to the bulb in Problem (2) by 6.3 coulombs of equivalent positive charge
 - c. How many joules of energy will be transferred to the bulb in Problem (2) in 5 seconds if equivalent positive charge is flowing through the bulb at the rate of 1.7×10^{-3} coulombs/sec
 4. The **voltage drop** V across a circuit element N as follows



tells us the number of joules/coulomb transferred between N and each coulomb of equivalent positive charge flowing through it. The unit of voltage is the **volt** defined as follows

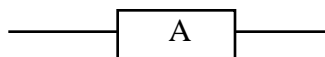
$$1 \text{ volt} = \frac{1 \text{ joule}}{\text{coulomb}}$$

- a. How many joules of energy is transferred between N and 5 coulombs of equivalent positive charge flowing through it if $V = 3.2$ volts
 - b. What is the voltage V across N if 10 joules of energy is transferred between N and every 2.5 coulombs of equivalent positive charge flowing through it
5. From the previous problems we know that voltage drops V across circuit elements enable us to calculate the amount of energy being transferred between the elements and the equivalent positive charges flowing through them. To specify which way energy is being transferred we add voltage reference directions as follows



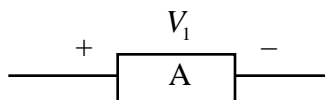
and then make V positive or negative as follows:

- (1) $V > 0$ if equivalent positive charge on the side with the plus has more energy than equivalent positive charge on the side with the minus
 - (2) $V < 0$ if equivalent positive charge on the side with the plus has less energy than equivalent position charge on the side with the minus
- a. What is the voltage drop V across A if 5 joules/coulombs is being transferred to A by equivalent positive charge flowing through it from left to right. Hint - the equivalent positive charge ends up with less energy after flowing through A
 - b. What is the voltage drop V across A if 5 joules/coulombs is being transferred to A by equivalent positive charge flowing through it from right to left
 - c. Which way is energy being transferred if $V = 5$ volts and equivalent positive charge is flowing from right to left
6. The objective of this problem is to see how reversing a voltage reference direction affects its value. Suppose in particular that the magnitude of the voltage drop across a circuit element A as follows

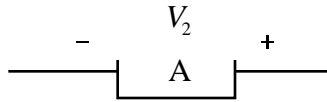


is 5 volts and that equivalent positive charges on the left side have more energy than equivalent positive charge on the right side

- a. What is V_1 with reference direction as follows

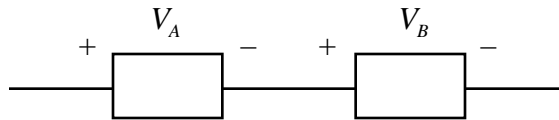


b. What is V_2 with the opposite reference direction as follows



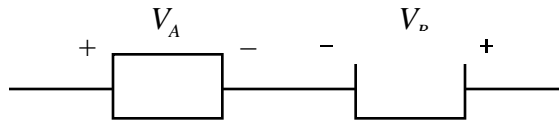
- c. How are V_1 and V_2 related. Write an equation for V_1 in terms of V_2 . **Memorize** this result forever
- d. How is your result in part (c) analogous to what happens when we reverse a current's reference arrow

7. Now suppose equivalent positive charge is flowing from left to right through two circuit elements as follows

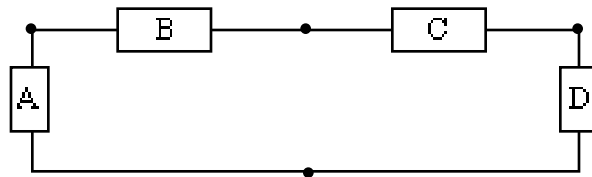


Will the equivalent positive charge end up with more energy or less energy if

- $V_A = 5$ volts and $V_B = 3$ volts
 - $V_A = 5$ volts and $V_B = -3$ volts
 - $V_A = -5$ volts and $V_B = 3$ volts
8. Repeat Problem (7) if the reference directions for V_A and V_B are as follows

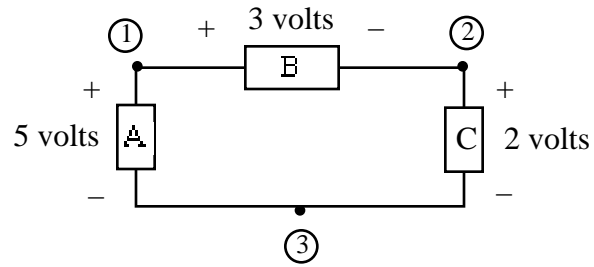


9. How would you expect an increase in the voltage across a light bulb to affect its current - the rate equivalent positive charge is flowing through it. Why
10. The purpose of this problem is to introduce **nodes** - the points where circuit elements are connected together as indicated in the following circuit with four nodes

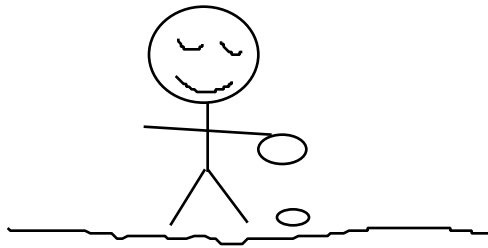


Memorize this definition. And then draw a circuit with three nodes

11. We say that node 1 is at a higher **potential** than node 2 if equivalent positive charge at node 1 has more energy than equivalent positive charge at node 2. Which node is at the highest potential in the following circuit. Explain how you know



12. And now, last but not least, explain how the operation of a flashlight is analogous to the cracking of nuts by lifting and then dropping rocks on them as illustrated by



13. Math Review: Sketch a graph of $V = -2 + 4000I$