ECE 207 - REVIEW OF RESISTOR CIRCUITS - INV 1
VOLTAGE, CURRENT, POWER, KIRCHHOFF'S LAWS

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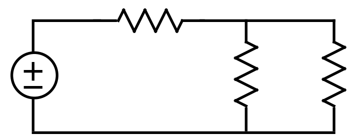
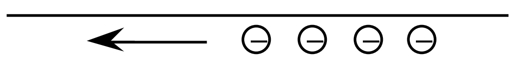
To do "well" on this investigation you must not only get the right answers but must also do neat, complete and concise writeups that make obvious what each problem is, how you're solving the problem and what your answer is. You also need to include drawings of all circuits as well as appropriate graphs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

The overall objectives of this class are to introduce controlled sources, capacitors and inductors; to develop methods for analyzing circuits containing them; and to investigate the basic properties of these circuits. To do all this we need to make use of the basic results we developed in ECE 109 to analyze linear resistor circuits – results we will be reviewing in this and the next three investigations. The main objectives of this investigation are to review current, voltage, power and Kirchhoff's Laws.

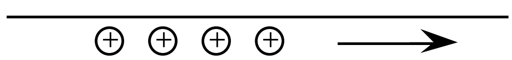
1. We begin with current. We know from ECE 109 that if we connect a source V_S to a circuit of resistors as follows



then negatively charged electrons will flow through the wires, through the resistors and then back to the source. We also know from ECE 109 that the electric and magnetic fields generated by the flow of these negative charges



are the same that would be generated by an equal number of positive charges flowing in the opposite direction as follows

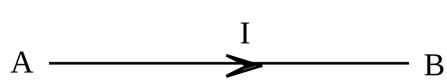


and so we say the two flows are **electrically equivalent**.

Now when Benjamin Franklin and his cohorts were first studying electric circuits in the 1700's they were able to surmise that something was probably flowing through them. But they really had no idea what it was – let alone its direction. So Franklin took a guess – a guess that turns out to correspond to the flow of **equivalent positive charge**. By tradition we follow Franklin's lead and use his **conventional current** to specify the currents in our circuits.

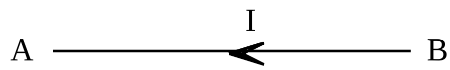
The objective of this and the next two problems is to review the **relationship** between the **directions** of the reference arrows, the **signs** of the currents and the **directions** the **equivalent positive charges** are flowing.

   a. Draw pictures like those above to illustrate which way equivalent positive charge is flowing through the following wire



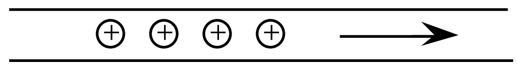
if (i) I = 3 ma (ii) I = – 3 ma

b. Repeat part (a) for

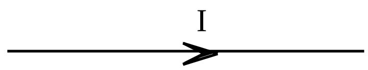


if (i) I = 3 ma (ii) I = – 3 ma

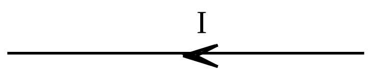
c. Now suppose that equivalent positive charge is flowing through a wire as follows



with each plus corresponding to 1 coul/sec. What is I if its reference direction is as follows

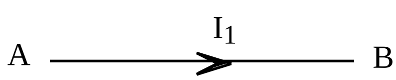


How about if I's reference direction is pointing in the opposite direction



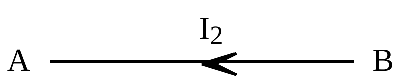
d. State in words the relationship between the direction of the reference arrow, the sign of the current and the direction the equivalent positive charge is flowing

2. Suppose an engineer measures the current I_1 = 5A for the following wire



a. Draw a picture to illustrate the direction the equivalent positive charges are flowing

b. Now suppose a second engineer measures the current through the same wire but with current reference arrow pointing in the opposite direction as follows

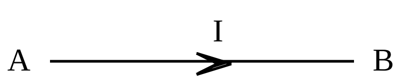


What would the second engineer measure for I_2. How do you know

c. Express I_1 as a function of I_2.

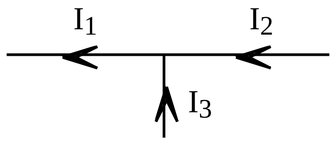
d. Describe in words how reversing the direction of a reference arrow affects the value of the corresponding current

3. Given the following wire



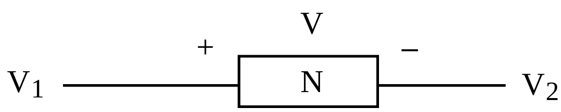
what additional information do you need to be able to determine the direction the equivalent positive charge is flowing

4. The objective of this problem is to review KCL. Given the following node



a. Draw a picture showing the directions the equivalent positive charges are flowing through each wire if $I_1 = -2A$, $I_2 = 1A$ and $I_3 = -3A$
b. Verify that the equivalent positive charge is flowing into the node at the same rate it's flowing out. A Table would be useful here.
c. Write the KCL equation for the algebraic sum of the currents **leaving** the node

5. Now for voltage. We know from ECE 109 that the voltage drop V across a circuit element like the following



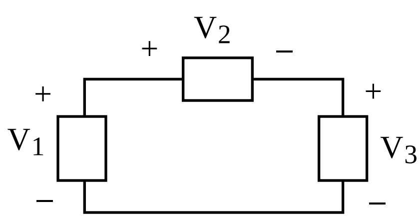
is the difference in potential

V = (Voltage at the node with a **plus**) – (Voltage at the node with a **minus**) = $V_1 - V_2$

where V_1 and V_2 are the corresponding node voltages. The voltage drop V in volts = joules/coulomb tells us the amount of energy per coulomb that is being transferred between N and the charges flowing through it.

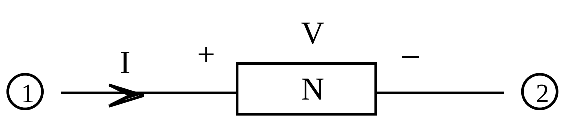
a. Find V if $V_1 = 3$ volts and $V_2 = 5$ volts
b. Find V if $V_1 = 5$ volts and $V_2 = 3$ volts
c. Do equivalent positive charges have more potential energy at node 1 or node 2 when $V_1 = -5$ volts and $V_2 = -3$ volts. How can you tell

6. The objective of this problem is to review KVL. Given the following circuit



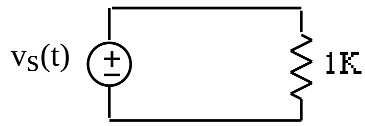
a. Write the KVL equation for this circuit
b. Express V_2 in terms of V_1 and V_3. **Memorize** this relationship
c. Express V_1 in terms of V_2 and V_3. **Memorize** this relationship

7. The objective of this and the next two problems is to review power and energy transfer. Are the equivalent positive charges flowing through the following circuit element



receiving energy from N or transferring energy to it if $V > 0$ and $I < 0$. How can you tell

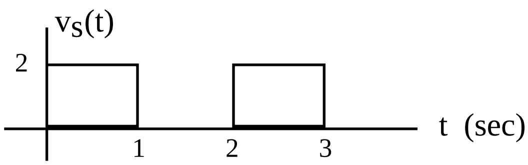
8. Given the following circuit



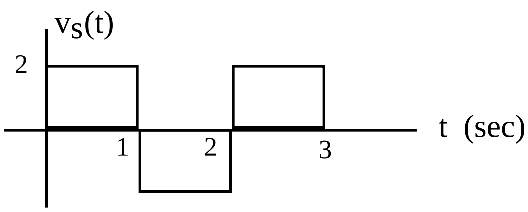
Sketch graphs of the power p(t) and then find the total energy transferred to the resistor when

a.

b.



c.



9. The objective of this and the following problems is to review some basic math. Is the voltage $v(t) = 2 \cos(3t)$ increasing or decreasing at $t = 5.5$ seconds. How can you tell

10. Given the two voltages $v_1(t) = 2t + 5$ and $v_2(t) = 3t + 2$

a. Which voltage is greater at $t = 1$ sec
b. Which voltage is changing faster at $t = 1$ sec. How can you tell

11. Draw a graph of a signal x(t) for $0 \le t \le 3$ that satisfies

$x' > 0$ when $0 \le t \le 1$
$x' = 0$ when $1 \le t \le 2$
$x' < 0$ when $2 \le t \le 3$