Section	Group	Name	Signature
Grade			
		Jacob Harkins	Jacob Harkins

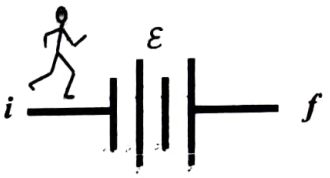
Materials: • PhET Circuit Construction Kit: DC

After this activity you should know: • *Kirchoff's Junction Law* • *Kirchoff's Junction Law* • *Kirchoff's Loop Law* • *Sign of voltage differences as one crosses EMFs, resistors and capacitors in a circuit* • *how to use Kirchoff's laws to solve multi-loop circuits* • *how to use Kirchoff's law to find voltage difference between any two points in a circuit.*

1. Counting voltage changes: Consider someone walking along a circuit and counting the change in voltage as they cross different circuit elements. Determine the voltage change $\Delta V = V_f - V_i$ for each case below.

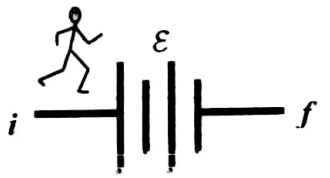
   a. Cross an EMF from the negative to positive terminal:

   • $\Delta V = +\mathcal{E}$ • $\Delta V = -\mathcal{E}$



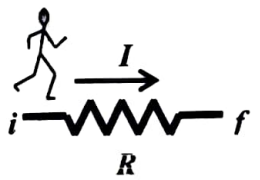
   b. Cross an EMF from the positive to negative terminal:

   • $\Delta V = +\mathcal{E}$ • $\Delta V = -\mathcal{E}$



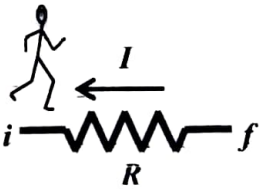
   c. Cross a resistor R in the same direction as the current I:

   • $\Delta V = +I\,R$ • $\Delta V = -I\,R$



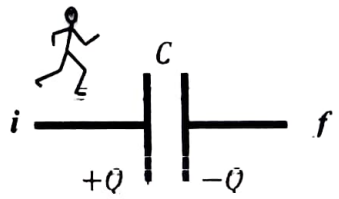
   d. Cross a resistor R opposite the direction of the current I:

   • $\Delta V = +I\,R$ • $\Delta V = -I\,R$



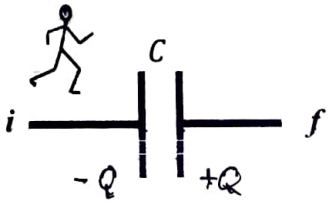
   e. Cross a capacitor C from the positive to negative plate:

   • $\Delta V = +\frac{Q}{C}$ • $\Delta V = -\frac{Q}{C}$



   f. Cross a capacitor C from the negative to positive plate:

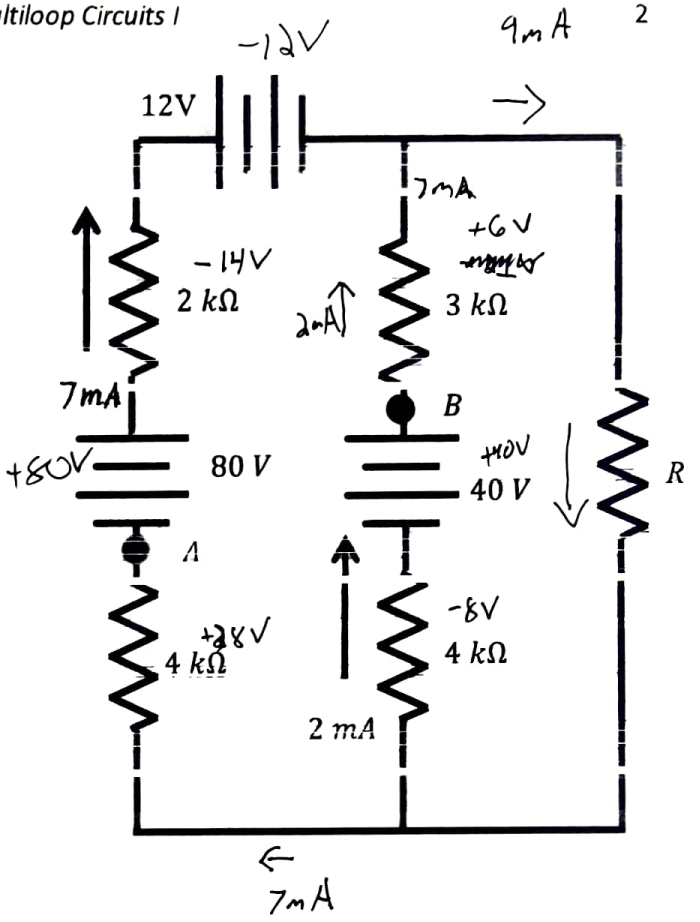
   • $\Delta V = +\frac{Q}{C}$ • $\Delta V = -\frac{Q}{C}$



2. A multi-loop circuit of 5 resistors and 3 EMFs is shown.

   a. Determine the voltage difference $\Delta V = V_B - V_A$ between points A and B in the circuit shown. Show work.

   Hint: start at point A and use the ΔV rules to count the total voltage difference. Be careful with the signs. You do not need the loop rule since you should know all the currents involved. Try two different paths to check your answer.



$80V - 14V - 12V + 6V = 60V$

$28V - 8V + 40V = 60V$ ✓

   b. State Kirchoff's Junction Rule.

Sum of the currents going into a junction = Sum of currents going out.

   c. Determine the magnitude and direction (top of page/bottom of page) of the current through the resistor R on the rightmost branch.

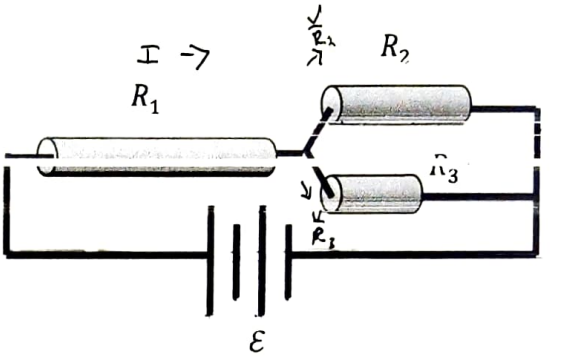
9mA down

   d. Determine the resistance R by applying Kirchoff's Loop Rule to the loop formed by the resistor R, the 4 $k\Omega$, resistor the 40V EMF and the 3 $k\Omega$ resistor.

$-9R - 8V + 40V - 6V = 0$

$R = \frac{26}{9} k\Omega$

3. The three cylindrical resistors are all made of the same material and have the same diameter but have different lengths. They are connected to an EMF as shown.



   a. Rank the currents through the resistors from largest to smallest. Place an equal sign between any entries that you think are equal.

$R_1 > R_3 > R_2$

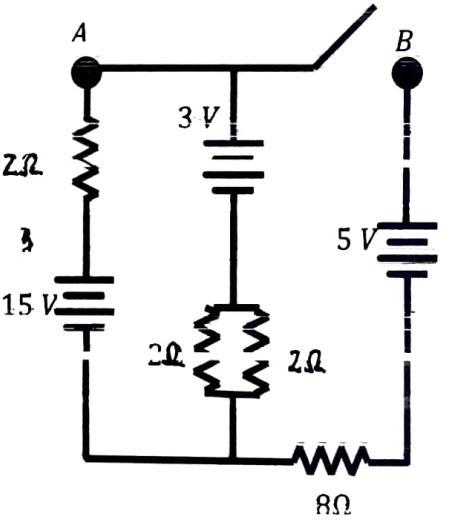
LARGEST: _____ _____ _____ SMALLEST

   b. Rank the voltage drops across the resistors from largest to smallest. Place an equal sign between any entries that you think are equal.

$R_1 > R_1 = R_3$

LARGEST: _____ _____ _____ SMALLEST

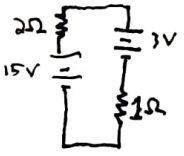
4. Resistors and EMFs are connected as shown.



   a. What is the current through the 8Ω resistor? *Hint: no calculation should be needed.*

0

   b. What the magnitude and direction of the current through the 3V EMF? *Hint: Simplify the circuit first.*



12V 3Ω $I = \frac{12V}{3\Omega} = 4A$.

   c. What is the voltage difference $V_B - V_A$?

$V_B - V_A = -8V$

$V_A = 2 \cdot 4 = 8V$

$V_B = 0 \cdot 1 = 0V$

   d. What is the total energy dissipated by all the resistors in the circuit in 24 hours? Give the answer both in Joules and in kilowatt-hours.

$P = I^2R = 24\left(\frac{1}{1000}\left(4^2 \cdot 3\right)\right) = 1.152\ Kw\,hr$

$= 0.048\ Kw \cdot 3600000\ \frac{J}{Kw} = 172,800\ J$

   e. Build the circuit using the PhET Circuit Construction Kit: DC simulation and check that your answer for $\Delta V = V_B - V_A$ is correct.