Tuesday: 11-11:50am – GS 222
Tuesday: 6-6:50pm – GS 110
Thursday: 11-11:50 am – GS 222
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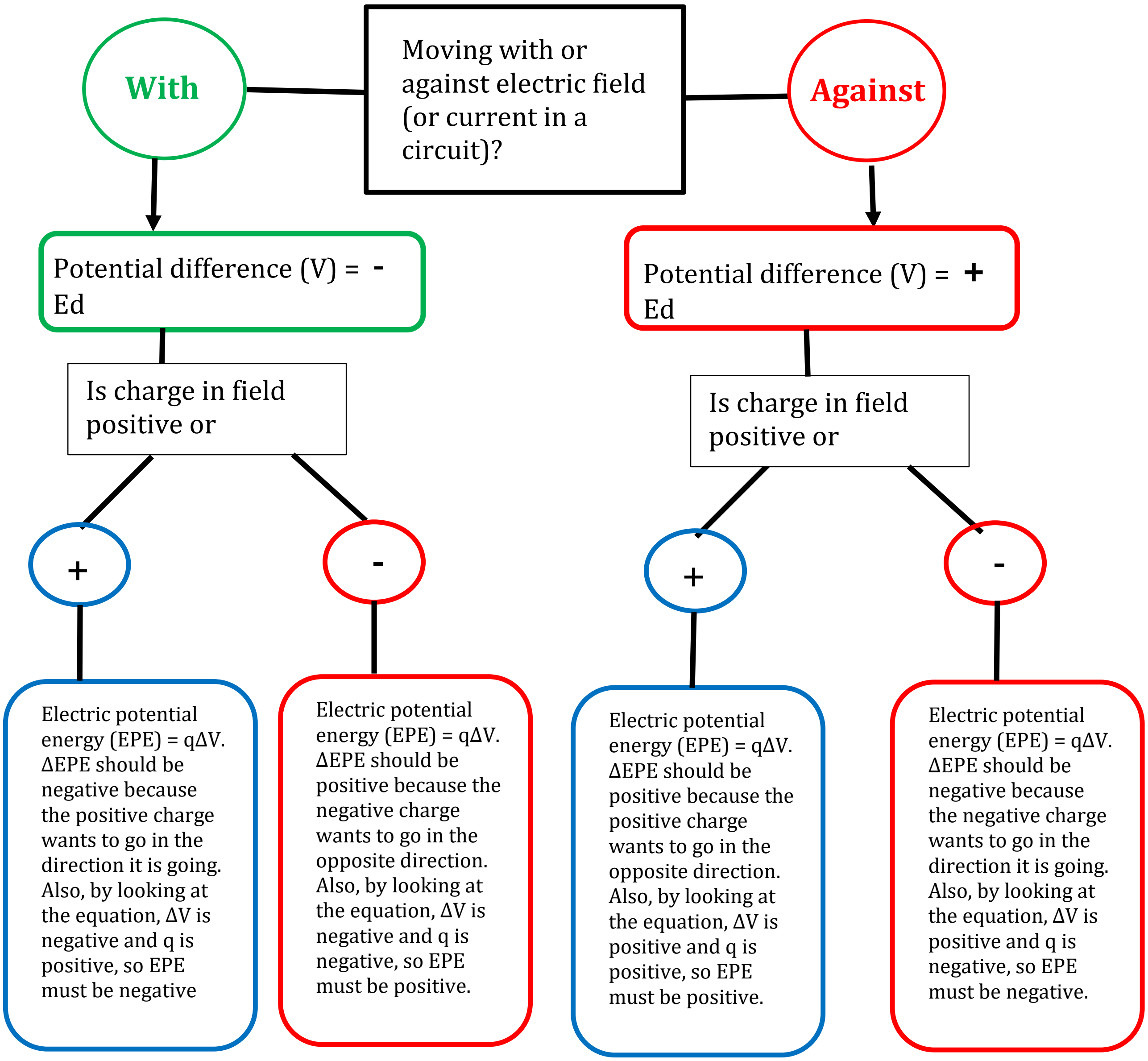
PHY2054 Exam 2 Review

1. Potential Difference and Electric Potential Energy in a **uniform** electric field
    a. Electric potential energy (EPE) of a point charge in a uniform electric field depends on two things:
        i. Whether the point charge is positive or negative
        ii. Whether it is moving with or against the electric field
    b. Potential difference (V) only depends on the electric field and whether you are moving with or against it
        i. Does not depend on, or even require, a charge to measure, but we can calculate the potential difference (V) for a charge moving in a uniform electric field
    c. To calculate the change in potential energy on a charge moving in some uniform electric field, it is best to find the change in potential difference first
        i. $\Delta V = +/- Ed$ (sign depends on direction of movement)
        ii. $\Delta EPE = q\Delta V = qEd$ (no absolute value for the charge)
        iii. If charge is moved at an angle to the field, use cos or sin to find the amount it was actually moved parallel to the field
        iv. Neither EPE or V change when you move perpendicular to the electric field



Example 1

Suppose you have a parallel plate capacitor with surface charge density of $9\mu C/m^2$ and are 0.7 meters apart. The positive plate is on top. (I will draw it on the board)

a. What is the magnitude and direction of E?

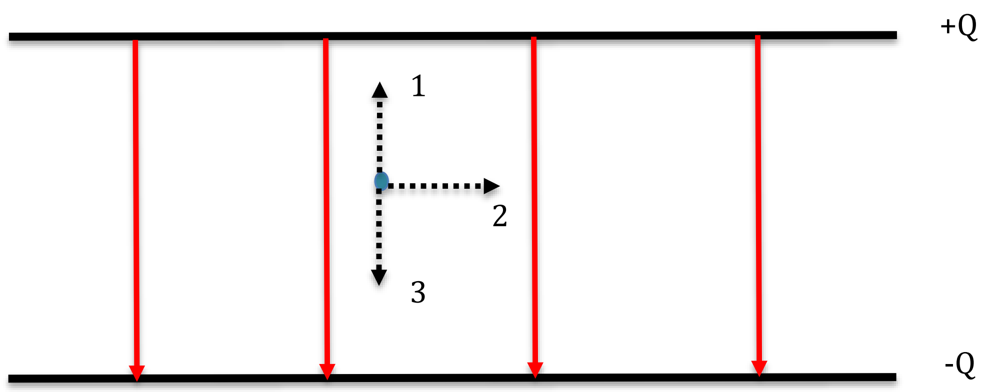
b. What is the Potential Difference between the plates?

c. If a +4μC point charge with mass of .2kg is placed 0.3 meters above the bottom plate, what is its Electric Potential Energy at that point?

d. If the point charge from part d moves .2m in the +y direction (toward the positive plate) what is its change in Voltage and Electric Potential Energy?

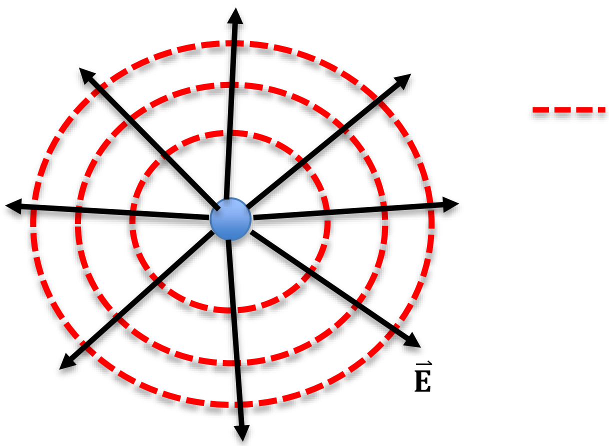
e. If it started at 12.2 m/s in part d, what is the final velocity of the charge when it makes it .2m from where it started?

Example 2



	Positive Charge	Negative Charge
ΔEPE		
ΔV		

2. Potential difference in a **non-uniform** electric field
    a. Remember point charges create non-uniform electric fields
        i. Electric field travels away from positive charge/towards negative point charge
        ii. Non-uniform field means that the electric field from a point charge changes in magnitude depending on the distance from the charge
            1. We can see this from the equation for potential: $V=kq/r$, where q can be positive or negative



Equipotential Lines (along each line the electric potential is equal, but between the lines it is different)

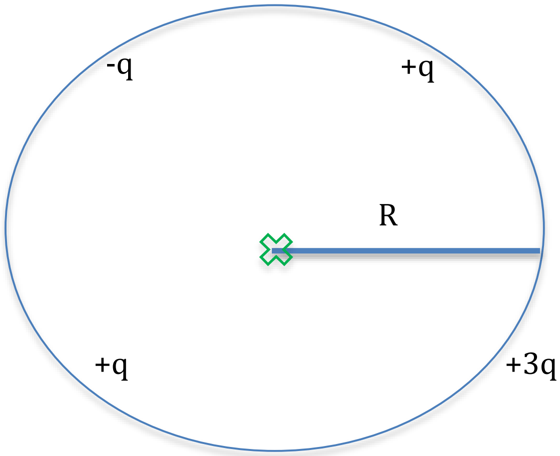
    b. To measure the electric potential at a point some distance, r, away from a point charge, simply use the equation above and remember the q does not have an absolute value. Therefore, V can be positive or negative depending on the charge.
        i. To measure the electric potential at a point near multiple charges, calculate V for each charge at the point and simply add them all up.

Example 3

Suppose we have 4 point charges and want to measure the total electric potential from them all at a point chosen at the origin. q1=-7 micro-coulombs, q2=4 micro-coulombs, and q3=4 micro-coulombs and q1 is located at (-.2m, .3m), q2 is located at (0m, -.25m), and q3 is located at (.4m, .1m).

Example 4

a. Give the equation for the total electric potential at the point illustrated below, where all charges shown are on the surface of the circle:



b. Suppose we had the value of q and had R and were able to calculate the total V at the point to be 10.6V. If we placed a negative point charge where the point was and wanted to calculate the electric potential energy on the new charge, how could we do it?

3. Capacitors and Capacitance
    a. Capacitance is how much charge a capacitor can hold
        i. **Capacitance itself only depends on the distance between the plates and the area of each plate**
            1. $C = \frac{\varepsilon_0 A}{d}$
        ii. If the distance between the plates *increases* by some amount, the capacitance *decreases* by the same amount
            1. If capacitance decreases, the capacitor holds less charge
        iii. If the area of the plates increases by some amount, the capacitance will increase as well
            1. Capacitor will hold store more charge
    b. The total charge of the plates, Q, can be determined if we know the capacitance and voltage across the plates.
        i. Q=CV

ii. And remember, Voltage=Ed

c. Capacitors connected/unconnected to a battery
   i. When a capacitor is connected to a battery, the voltage across it is constant and is equal to the voltage of the battery
   ii. Capacitance can still change if distance between the plates or area of the plates changes
      1. Q changes proportionally to C since V is constant when connected to a battery
      2. E changes inversely to the distance, since E=V/d and V is constant

d. Capacitors removed from battery
   i. Charge is constant, once removed from the battery
      1. If you knew the charge, Q, before disconnecting the battery, it is the same after disconnecting and won't change.
      2. Capacitance and voltage can still change
         a. If capacitance changes because we change the distance between the plates, the voltage must change inversely to the capacitance since Q is constant

e. Dielectrics are insulators placed between a capacitor
   i. The electric field causes their atoms to form dipoles because the electrons can't readily leave the atoms in an insulator
      1. As a result, the atoms themselves form an electric field opposite that of the electric field from the capacitor
         a. Reduces the original electric field
   ii. Dielectrics **increase** the capacitance of an **isolated** capacitor
   iii. If you already know C before inserting the dielectric, the new C can be found by multiplying the dielectric constant, κ, by the old C.
      1. $C = \kappa C = \frac{\kappa \varepsilon_0 A}{d}$

Example 5

Suppose we have a capacitor with capacitance of 3.4×10^{-9}F. If the original distance between the plates is .7m, and we change the distance to .35m, what is the new capacitance? What is we changed the distance *and* doubled the area?

Example 6

Suppose you have a parallel plate capacitor with surface charge density of 9μC/m^2 and are 0.7 meters apart. The positive plate is on top. (I will draw it on the board)

a. If the Capacitance is 4x10^-9 F, what is the Area of the plates?

b. Based on your answer in part a, what's the charge in the positive plate?

c. What is the Potential Difference of the Capacitor?

d. If you increase the length of the plate by a factor of 3 and decrease the width by a factor of 2, what is the Capacitance?

e. If the plates from part d are attached to a 20V battery, what is the new capacitance and charge?

f. If the battery is disconnected and a dielectric with constant `k=1.6` what is the stored energy? Remember that when a battery is disconnected from the capacitor, the charge on each plate (Q) never changes. First find the new capacitance of the capacitor with the dielectric (hint: multiply the old capacitance by 1.6), then find how the voltage changes as a result.

g. What's the energy density of the capacitor?

4. Resistor Circuits
   a. Current, I, moves from the positive terminal to the negative terminal
   b. Resistors act to resist, or lower, current and voltage in the circuit
   c. V=IR

Example 7

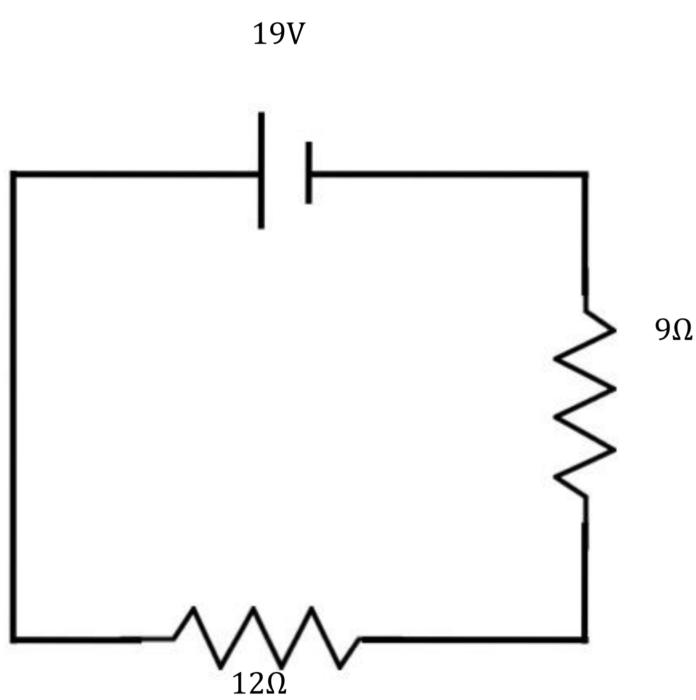
Suppose we have a circuit with only one resistor of 6Ohms and a battery of 25V.
What is the total current in the circuit?
What is the current through the resistor?
What is the voltage across the resistor?

What is the power output of the battery?

d. If the current travels through the battery from the negative end to the positive end, the power produced by the battery is positive; if the current goes the wrong way, the power is negative.
    i. Power dissipated by all resistors is equal to the power created by all batteries

e. Resistors in series
    i. Need to find equivalent resistance to find total current in circuit
        1. Just add up all resistances when in series
        2. Same amount of current flows through each resistor
    ii. Removing a resistor in series increases the power output of the battery

Example 8



Find the equivalent resistance

Find the total current through the circuit

What is the current through resistor 1? What about resistor 2? What about the battery?

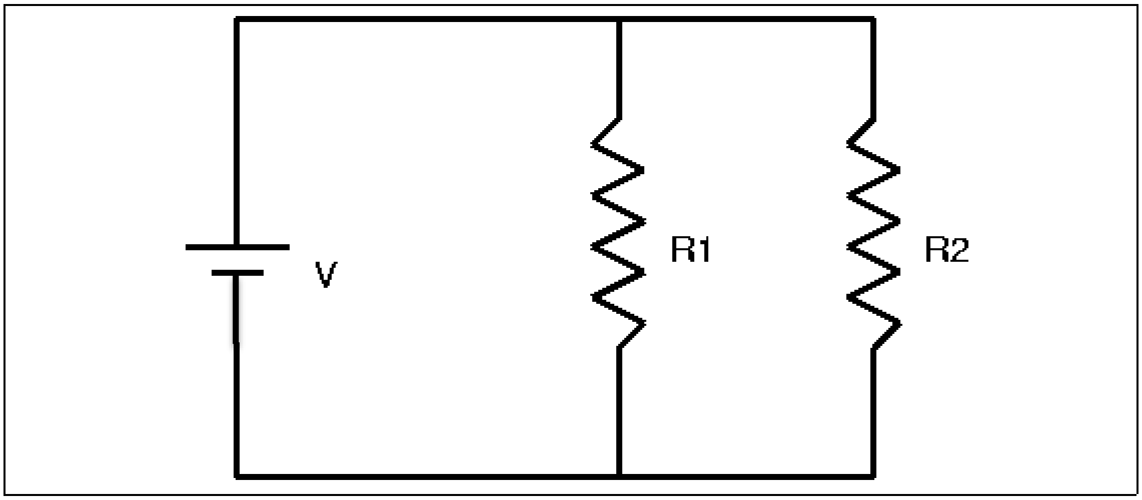
Should the voltage across resistor 1 equal that of resistor 2? Why?

What is the power dissipated by resistor 2?

f. Resistors in parallel
   i. When resistors are connected in parallel, the current can take different routes through the current
   ii. The voltage across resistors connected in parallel is the same
   iii. Find the equivalent resistance with the following equation:
      1. $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} \ldots$
   iv. Although the voltage is the same across the resistors, the current going through each path is different
      1. $I = I_1 + I_2$
   v. Least resistance consumes most power in parallel

vi. Removing a resistor in parallel decreases power output of battery

Example 9



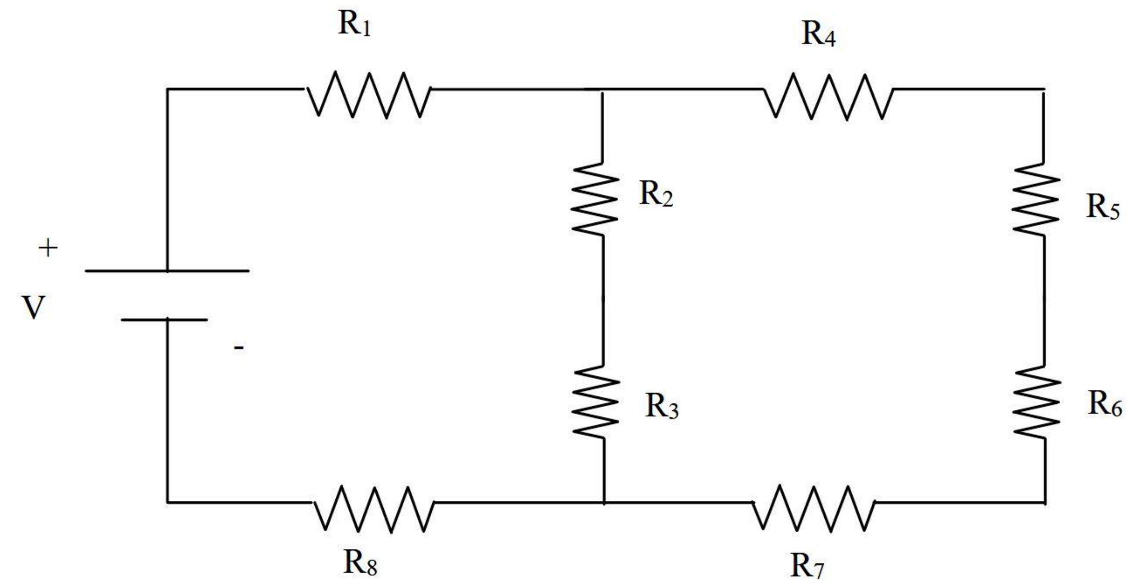
What is the voltage across R2? What about R1?

If R1=9 Ohms and R2=12 Ohms, find the equivalent resistance.

Find the total current through the circuit if the voltage of the battery is 15V.

What is the current through R2?

Example 10



V=23V; R1=3.3Ohms; R2=9.9Ohms; R3=6.6Ohms; R4=2.1Ohms; R5=1.9Ohms; R6=4.9Ohms; R7=5.7Ohms; R8=6.5Ohms.

a. Draw the three different currents going through the circuit and write an equation to relate them to each other.

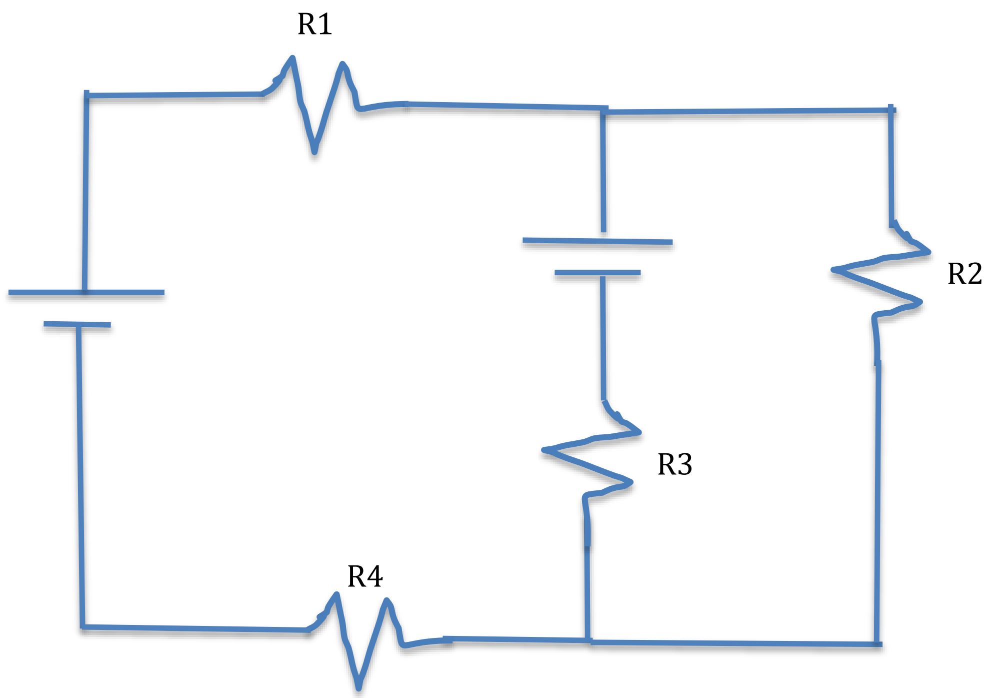
b. Find the equivalent resistance.

c. Find the total current through the circuit.

d. Find the power output of the battery and the power dissipated by the resistance.

e. Find the voltage across resistor 3 in Volts.

Example 11



The battery on the left is 15V and the battery on the right is 6V. R1=10ohms, R2=3ohms, R3=6ohms, and R4=9ohms.

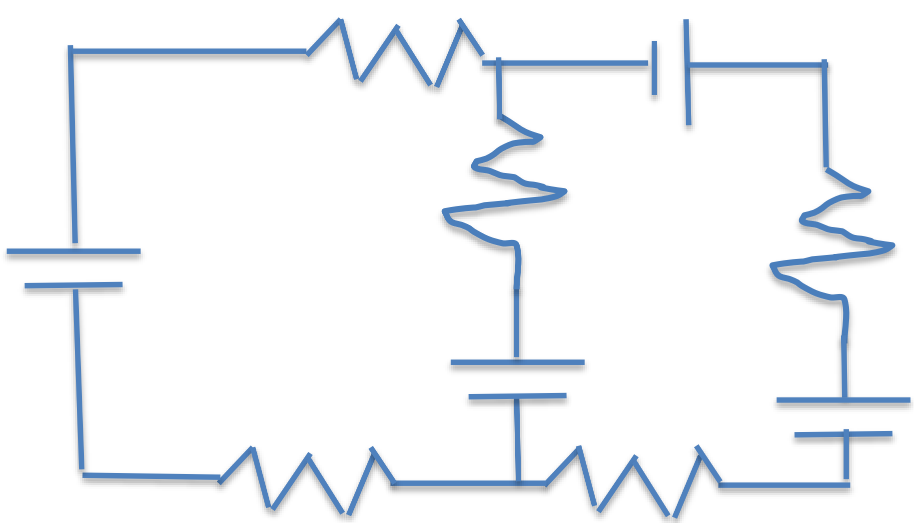
a. Write the three equations involving the three currents in the circuit:

b. Find the total current in the circuit, I.

c. Find I1 and I2.

d. What's the total power output of each battery?

Example 12

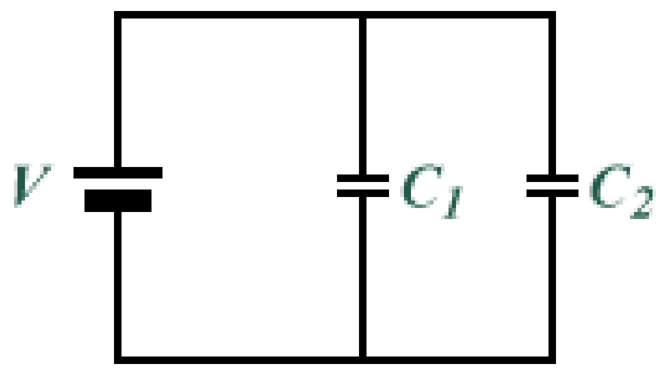


In the circuit above V1 = 12.1V, V2 = 5.9V, V3 = 17.2V, and V4 = 3.2V . V1 was used to guess the current direction. I=3.5A and travels clockwise from battery 1, and

I2=8A and travels clockwise around loop 2. What is the power dissipated by the resistors?

5. Capacitors in circuits
    a. Connecting capacitors in parallel is similar to connecting resistors in parallel with regard to the voltage across each one
    b. The charge in a capacitor, Q, equals the capacitance of that capacitor multiplied by the Voltage through it.
        i. If they are connected in parallel, to find the total charge in the circuit, add up the capacitances and multiply by the voltage.
        ii. We can see that the total charge is the same for all capacitors in parallel

Example 13



Suppose C1 was 3x10^-9F and C2was 2.3x10^-10F. What is the total capacitance?

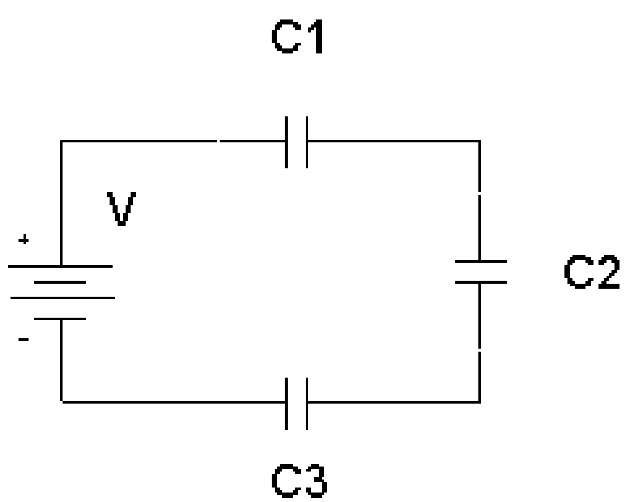
If V=25V, what is the total charge stored by both capacitors?

What is the voltage across each capacitor?

What is the charge stored by C2?

c. Capacitors in series
   i. 1/Ceq = 1/C1 + 1/C2 . . .
   ii. Total charge = Q=(Ceq)(V)
   iii. Remember the total charge (Q) is the same for each one

Example 14



If C1=2.3x10^-9F, C2=5.4x10^-11F, and C3=4.1x10^-10F, what is Ceq?

If the voltage of the battery is 19V, what is the total charge stored by the capacitors?

Extra Question

An AC unit uses 3,000 Watts of power when it is on. If during the summer, the AC unit is on for 18 hours in a day and the cost of electricity is $0.09/kwh, how much does it cost, in dollars, to run the AC per month if a month is 30 days?