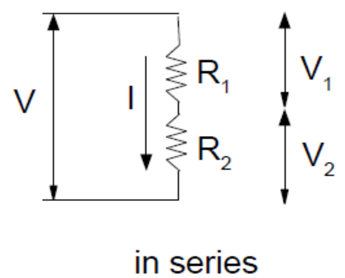
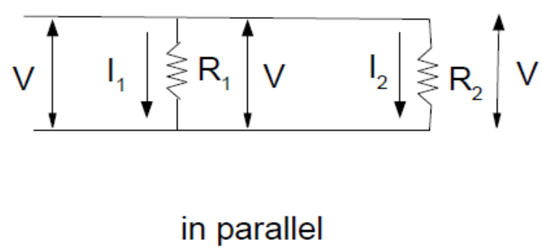
PHYS 1220, Engineering Physics, Chapter 26 – Direct-Current Circuits

Instructor: TeYu Chien
Department of Physics and Astronomy
University of Wyoming

Goal of this chapter is to learn how to analyze direct-current circuits

- Multiple resistors in circuit – equivalent resistance

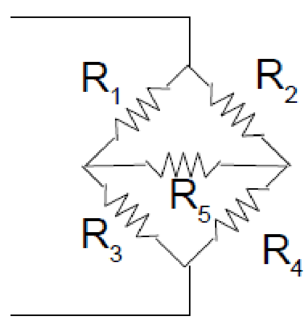




- When two resistors are in series, the current passing through each of them is the same.
  - $R_{eq} = R_1 + R_2$
- When two resistors are in parallel, the electric potential is the same.
  - $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$
- Equivalent resistance is the resistance that you measured from the two terminals regardless how complex the real resistor network is. In other words, when analyzing circuit, you can simplify multiple resistors into one equivalent resistor.

You Do Example 26.1 on page 853
I Do Problem Excercise 26.14 on page 876

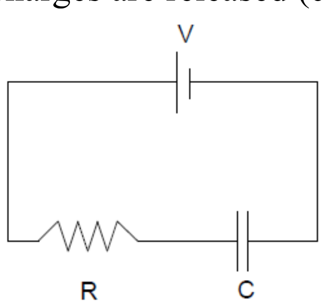
- But what if you encounter a complicate circuit that cannot be breakdown to either parallel or series connections? For example:



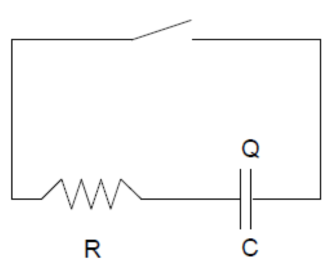
- This could be solved by Kirchhoff's Rules
  - **Junction rule:** $\sum I=0$ at any junction
  - **Loop rule:** $\sum V=0$ for any closed loop
  - Note: V and I, though are not vectors, they could be either positive or negative.
  - Strategy:
    (1) for each section of wire, define current notation (such as I_1 , I_2 , I_3 etc...) AND direction. At this moment, it doesn't matter which direction the current should be. If you defined a wrong direction for one particular current, the answer will just become negative. (The sign will correct the direction of the current).
    (2) Use Junction rule, you should be able to construct equations relating individual currents together. The number of nodes in the circuit will be the number of equation you may have.
    (3) Choose any certain point as starting point, then choose a travel route of a closed loop (you need to travel back to the original point).
    (4) Use Loop rule to construct electric potential relationship in the circuit. Note, when traveling passing a resistor if the **travel direction** is the same (opposite) as the **current direction**, the electric potential will drop (raise). This gives: $-IR$ (IR).
    (5) Choose different route of another closed loop (the new route may contain some sections that are used in old route, but it should contain new sections that never been used by other old routes). You need to consume all the sections in the circuits to construct equations using Loop rule.
    (6) Finally, solve multiple unknown variable (the unknown currents) with multiple equations you constructed using Junction rule and Loop rule above.

You Do Example 26.6 on page 859
I Do Problem 26.61(a) on page 879

- Now, let's consider the circuit that contains both resistors and capacitors
  - Remember that capacitor is constructed by two separated conducting plates. In direct current circuit, it will store charges and then stop when reach the maximum charge at that electric potential (charging process) or release charges and then stop when all the charges are released (discharging process).



Charging process



Discharging process

- For charging process: $q(t)=Q_f(1-e^{-t/RC})$; $i(t)=I_0 e^{-t/RC}$
- For discharging process: $q(t)=Q_0 e^{-t/RC}$; $i(t)=I_0 e^{-t/RC}$
- Time constant: $\tau=RC$. This time constant is defined as when the value reaches e^{-1} of the original value. Why defined this way? Just one convenient way to define it. Another equally convenient way is to define the value reaches to ½ (or 2^{-1}) of the original value. (Blue colored text will not be included in exam, but should be useful for you to understand broader concepts)

- How are the electronics hooked onto the power distribution systems in household?

- See Figure 26.24 on page 869. They are having common neutral line (ground) and a common hot line (high voltage).

- Human body has huge, but not infinite, resistance. If our daily used electronics (such as hair dryer) has circuit fail and the hot line is exposed and is touched by you. What will happen? How to prevent it?

Skip Section 26.3

Math Preview for Chapter 27:

- Vector outer product
- Integration over an area to calculate flux

Questions to think about for Chapter 27:

- We already know that electron in electric field will feel an electric force that push/pull on the electron. We also know, similar to electric field, there is something called "magnetic field". Will an electron in magnetic field feels force due to the presence of the magnetic field?
- If I tell you that an electron will feel force due to the presence of the magnetic field. Then, for a conducting wire with electric field in it, we know electrons will move toward the opposite direction of the electric field. Now, let's assume this wire is also placed in magnetic field, will electrons move toward another direction that is not well aligned with the opposite direction of electric field?