



Electricity and Magnetism

A. Electrostatics (Ch 15 & 16)

Charge and Coulomb's Law:

Students should understand the concept of electric charge so they can:

- ◆ Describe the types of charge and the attraction and repulsion of charges. (15.1)
- ◆ Describe polarization and induced charges. (15.2)

Students should understand Coulomb's Law and the principle of superposition so they can:

- ◆ Calculate the magnitude and direction of the force on a positive or negative charge due to other specified point charges. (15.3)
- ◆ Analyze the motion of a particle of specified charge and mass under the influence of an electrostatic force. (15.3)

Electric Field and Electric Potential (Including Point Charges):

Students should understand the concept of electric field so they can:

- ◆ Define it in terms of the force on a test charge. (15.4)
- ◆ Describe and calculate the electric field of a single point charge. (15.4)
- ◆ Calculate the magnitude and direction of the electric field produced by two or more point charges. (15.4)
- ◆ Calculate the magnitude and direction of the force on a positive or negative charge placed in a specified field. (15.4)
- ◆ Interpret an electric field diagram. (15.5)
- ◆ Analyze the motion of a particle of specified charge and mass in a uniform electric field. (15.3 – 15.4)

Students should understand the concept of electric potential so they can:

- ◆ Determine the electric potential in the vicinity of one or more point charges. (16.2)
- ◆ Calculate the electrical work done on a charge or use conservation of energy to determine the speed of a charge that moves through a specified potential difference. (16.1)
- ◆ Determine the direction and approximate magnitude of the electric field at various positions given a sketch of equipotentials. (16.4)
- ◆ Calculate the potential difference between two points in a uniform electric field, and state which point is at the higher potential. (16.1)
- ◆ Calculate how much work is required to move a test charge from one location to another in the field of fixed point charges. (16.2)
- ◆ Calculate the electrostatic potential energy of a system of two or more point charges, and calculate how much work is required to establish the charge system. (16.2)

Equations – Electrostatics (Ch 15 & 16):

$$F = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_1 \cdot q_2}{r^2}$$

$$E = \frac{F}{q}$$

$$U_E = q \cdot V = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_1 \cdot q_2}{r}$$

$$E_{avg} = -\frac{V}{d}$$

$$V = \frac{1}{4\pi\epsilon_0} \cdot \sum \frac{q_i}{r_i}$$

B. Conductors, Capacitors, Dielectrics (Ch 15 & 16)

Electrostatics with Conductors:

Students should understand the nature of electric fields in and around conductors so they can:

- ◆ Explain the mechanics responsible for the absence of electric field inside a conductor, and know that all excess charge must reside on the surface of the conductor. (15.6)
- ◆ Explain why a conductor must be an equipotential, and apply this principle in analyzing what happens when conductors are connected by wires. (15.6)

Students should be able to describe and sketch a graph of the electric field and potential inside and outside a charged conducting sphere. (15.6)

Students should understand induced charge and electrostatic shielding so they can:

- ◆ Describe the process of charging by induction. (15.2)
- ◆ Explain why a neutral conductor is attracted to a charged object. (15.2)

Capacitors:

Students should know the definition and function of capacitance so they can:

- ◆ Relate stored charge and voltage for a capacitor. (16.6)
- ◆ Relate voltage, charge, and stored energy for a capacitor. (16.9)
- ◆ Recognize situations in which energy stored in a capacitor is converted to other forms. (16.9)

Students should understand the physics of the parallel-plate capacitor so they can:

- ◆ Describe the electric field inside the capacitor, and relate the strength of this field to the potential difference between the plates and the plate separation. (16.6 – 16.7)
- ◆ Determine how changes in dimension will affect the value of the capacitance. (16.6 – 16.7)

Equations – Conductors, Capacitors, Dielectrics (Ch 15 & 16):

$$C = \frac{Q}{V}$$

$$C = \frac{\epsilon_0 \cdot A}{d}$$

$$U_C = \frac{1}{2} \cdot Q \cdot V = \frac{1}{2} \cdot C \cdot V^2$$

C. Electric Circuits (Ch 16 & 17)

Capacitors in Circuits:

Students should understand the behavior of capacitors connected in series or in parallel so they can:

- ◆ Calculate the equivalent capacitance of a series or parallel combination. (16.8)
- ◆ Describe how stored charge is divided between two capacitors connected in parallel. (16.8)
- ◆ Determine the ratio of voltages for two capacitors connected in series. (16.8)

Equations – Capacitors in Circuits (Ch 16):

$$C_P = \sum C_i$$

$$\frac{1}{C_s} = \sum \frac{1}{C_i}$$

C. Electric Circuits (*Ch 16 & 17*)

Current, Resistance, and Power:

Students should understand the definition of electric current so they can:

- ◆ Relate the magnitude and direction of the current to the rate of flow of positive and negative charge. (*17.1*)

Students should understand conductivity, resistivity, and resistance so they can:

- ◆ Relate current and voltage for a resistor. (*17.4*)
- ◆ Describe how the resistance of a resistor depends upon its length and cross-sectional area and apply this result in comparing current flow in resistors of different material or different geometry. (*17.5*)
- ◆ Apply the relationships for the rate of heat production in a resistor. (*17.8*)

Equations – Current, Resistance, & Power (*Ch 17*):

$$I_{avg} = \frac{\Delta Q}{\Delta t}$$

$$R = \frac{\rho \cdot l}{A}$$

$$V = I \cdot R$$

$$P = I \cdot V$$