

III. ELECTRICITY AND MAGNETISM

- A. Electrostatics
- B. Conductors, capacitors, dielectrics
- C. Electric circuits
- D. Magnetic Fields
- E. Electromagnetism

A. Electrostatics

1. Charge and Coulomb's Law
2. Electric field and electric potential (including point charges)

1. Charge and Coulomb's Law

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

(1) Describe the types of charge and the attraction and repulsion of charges.

(2) Describe polarization and induced charges.

1. Charge and Coulomb's Law

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

(1) Calculate the magnitude and direction of the force on a positive or negative charge due to other specified point charges.

(2) Analyze the motion of a particle of specified charge and mass under the influence of an electrostatic force.

2. Electric field and electric potential (including point charges)

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

- (1) Define it in terms of the force on a test charge.
- (2) Describe and calculate the electric field of a single point charge.
- (3) Calculate the magnitude and direction of the electric field produced by two or more point charges.
- (4) Calculate the magnitude and direction of the force on a positive or negative charge placed in a specified field.
- (5) Interpret an electric field diagram.
- (6) Analyze the motion of a particle of specified charge and mass in a uniform electric field.

2. Electric field and electric potential (including point charges)

- (1) Determine the electric potential in the vicinity of one or more point charges.
- (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.
- (3) Determine the direction and approximate magnitude of the electric field at various positions given a sketch of equipotentials.
- (4) Calculate the potential difference between two points in a uniform electric field, and state which point is at the higher potential.
- (5) Calculate how much work is required to move a test charge from one location to another in the field of fixed point charges.
- (6) 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.

B. Conductors, capacitors, dielectrics

1. Electrostatics with conductors
2. Capacitors

1. Electrostatics with conductors

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

(1) 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.

(2) Explain why a conductor must be an equipotential, and apply this principle in analyzing what happens when conductors are connected by wires.

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

1. Electrostatics with conductors

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

(1) Describe the process of charging by induction.

(2) Explain why a neutral conductor is attracted to a charged object.

2. Capacitors

a) Students should understand the definition and function of capacitance, so they can:

(1) Relate stored charge and voltage for a capacitor.

(2) Relate voltage, charge, and stored energy for a capacitor.

(3) Recognize situations in which energy stored in a capacitor is converted to other forms.

2. Capacitors

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

(1) 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.

(4) Determine how changes in dimension will affect the value of the capacitance.

C. Electric Circuits

1. Current, resistance, power
2. Steady-state direct current circuits with batteries and resistors only
3. Capacitors in circuits

1. Current, resistance, power

a) 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.

1. Current, resistance, power

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

(1) Relate current and voltage for a resistor.

(3) 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.

(6) Apply the relationships for the rate of heat production in a resistor.

2. Steady-state direct current

circuits with batteries and resistors

a) Students should understand the behavior of series and parallel combinations of resistors, so they can:

(1) Identify on a circuit diagram whether resistors are in series or in parallel.

(2) Determine the ratio of the voltages across resistors connected in series or the ratio of the currents through resistors connected in parallel.

(3) Calculate the equivalent resistance of a network of resistors that can be broken down into series and parallel combinations.

(4) Calculate the voltage, current, and power dissipation for any resistor in such a network of resistors connected to a single power supply.

(5) Design a simple series-parallel circuit that produces a given current through and potential difference across one specified component, and draw a diagram for the circuit using conventional symbols.

2. Steady-state direct current circuits with batteries and resistors only

b) Students should understand the properties of ideal and real batteries, so they can:

(1) Calculate the terminal voltage of a battery of specified emf and internal resistance from which a known current is flowing.

2. Steady-state direct current circuits with batteries and resistors only

c) Students should be able to apply Ohm's law and Kirchhoff's rules to direct-current circuits, in order to:

(1) Determine a single unknown current, voltage, or resistance.

2. Steady-state direct current circuits with batteries and resistors only

d) Students should understand the properties of voltmeters and ammeters, so they can:

(1) State whether the resistance of each is high or low.

(2) Identify or show correct methods of connecting meters into circuits in order to measure voltage or current.

3. Capacitors in circuits

a) Students should understand the and steady-state behavior of capacitors connected in series or in parallel, so they can

(1) Calculate the equivalent capacitance of a series or parallel combination.

(2) Describe how stored charge is divided between capacitors connected in parallel.

(3) Determine the ratio of voltages for capacitors connected in series.

(4) Calculate the voltage or stored charge, under steady-state conditions, for a capacitor connected to a circuit consisting of a battery and resistors.