

Objectives for Material to be Learned from Unit 1

By the end of this unit, students should be able to do the following:

- 1.1 (Continuing objective) Describe applications of the concepts of electricity and magnetism to everyday “real-life” situations.
- 1.2 Describe the properties of charge, including that there are two types of charge, that opposites attract and likes repel, that electrons and protons have fundamental charge magnitude e , and that charge is conserved. Be able to relate an amount of charge in units of coulombs to a number of fundamental charges.
- 1.3 Use Coulomb’s Law to calculate electric forces. Specifically, for a given configuration of a small number of point charges, calculate the total electric force (magnitude and direction) acting on any chosen charge, due to all the others.
- 1.4 Describe the physical difference between conductors and insulators.
- 1.5 Show (using sketches) how the proximity of a charged object causes redistribution of charge in a nearby object. Explain how this can result in attractive forces.
- 1.6 Relate the electric force on a charge to the electric field at the location of the charge.
- 1.7 For a point charge or a configuration of several point charges, calculate the electric field (magnitude and direction) at any given location.
- 1.8 From a physical sketch or verbal description of a continuous line or line segment of charge, perform the following steps in setting up the calculation of the electric field at a given point P . (a) Make a sketch, and choose a coordinate system and an integration variable. (b) On the sketch, mark a “non-special” piece of charge dq , and label its size using dx or dy or $Rd\theta$ as appropriate. (c) Generate correct expressions for r and dq , in terms of the integration variable. Substitute these expressions into $dE = kdq/r^2$ to determine dE from the marked piece of charge. (d) Determine the correct limits of integration. (e) Determine the geometric factors by which dE should be multiplied to get the components $(dE)_x$ and $(dE)_y$. (f) Integrate $(dE)_x$ and $(dE)_y$ to find the components of the total electric field.
- 1.9 Represent and interpret electric fields using both field line and vector field diagrams.
- 1.10 Relate the electric flux through a surface to the electric field and geometry of the surface.
- 1.11 Use Gauss’s Law to relate electric flux through a closed surface to the net enclosed charge.
- 1.12 Use Gauss’s Law to calculate the electric fields due to symmetric charge distributions.
- 1.13 Correctly use expressions for the electric field due to an infinite line of charge or an infinite sheet of charge.
- 1.14 For a uniform electric field, relate \vec{E} to the potential difference between two points in the field.
- 1.15 Calculate the electric potential for a system of point charges, using superposition.

- 1.16** For a given physical arrangement of charges and fields, relate electric potential difference, potential energy change, work, and kinetic energy change.
- 1.17** Use the definition of current and Ohm's Law to relate current, charge, potential difference, and resistance.
- 1.18** Calculate the power produced or required by an electric system, given an appropriate combination of voltage, current, and resistance.
- 1.19** Calculate the force (magnitude and direction) acting on moving charges and current-carrying conductors in a magnetic field.
- 1.20** Starting from Newton's 2nd law, relate the velocity, magnetic field strength, and radius of curvature for a particle moving in a uniform magnetic field.
- 1.21** For a current loop or coil in a uniform magnetic field, calculate the magnetic moment, the torque on the coil, and the magnetic energy.
- 1.22** Correctly sketch the direction of the magnetic field in the vicinity of variously shaped magnets, especially near the North or South poles.
- 1.23** Use the Biot-Savart law and the right-hand rule to determine the magnitude and direction of a magnetic field due to a short current segment.
- 1.24** Distinguish and correctly use the expressions for the magnetic field for each of these special situations: (a) at the center of a circular loop or finite arcs of a circular loop; (b) a very long solenoid, (c) a long straight wire. Use these and superposition to find the total B-field due to a combination of sources.