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 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.

1.3 For a point charge or a configuration of several point charges, calculate the electric field (magnitude and direction) at any given location.

1.4 Relate the electric force on a charge to the electric field at the location of the charge.

1.5 Describe the physical difference between conductors and insulators.

1.6 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.

1.7 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.

1.8 Represent and interpret electric fields using both field line and vector field diagrams.

1.9 Use Gauss's Law to relate electric flux through a closed surface to the net enclosed charge.

1.10 Use Gauss's Law to calculate the electric fields due to symmetric charge distributions.

1.11 For a uniform electric field, relate $\vec{E}$ to the potential difference between two points in the field.

1.12 Calculate the electric potential for a system of point charges, using superposition.

1.13 For a given physical arrangement of charges and fields, relate electric potential difference, potential energy change, work, and kinetic energy change.

1.14 Use the definition of current and Ohm's Law to relate current, charge, potential difference, and resistance.

1.15 Calculate the power produced or required by an electric system, given an appropriate combination of voltage, current, and resistance.

1.16 Correctly sketch the direction of the magnetic field in the vicinity of variously shaped magnets, especially near the North or South poles.

1.17 Calculate the cross product of two vectors, determining both its magnitude and direction.

1.18 Calculate the force (magnitude and direction) acting on moving charges and current-carrying conductors in a magnetic field.

1.19 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.

1.20 For a current loop or coil in a uniform magnetic field, calculate the magnetic moment, the torque on the coil, and the magnetic energy.

1.21 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.

1.22 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) inside and just outside the central region of a very long solenoid, (c) outside a wire segment or long straight wire. Use these and superposition to find the total B-field due to a combination of sources.

1.23 Use Ampere's Law to relate the loop integral of $\vec{B}$ (circulation) to the net encircled current.

1.24 Use Ampere's Law to calculate the magnetic fields due to symmetric steady currents.