Module 6: Electromagnetism

Content

Charged Particles, Conductors and Electric and Magnetic Fields

Inquiry question: What happens to stationary and moving charged particles when they interact with an electric or magnetic field?

Students:

- investigate and quantitatively derive and analyse the interaction between charged particles and uniform electric fields, including:
  - electric field between parallel charged plates $E = \frac{V}{d}$
  - acceleration of charged particles by the electric field $\vec{F}_{\text{net}} = m\vec{a}, \vec{F} = q\vec{E}$
  - work done on the charge $W = qV, W = qEd, K = \frac{1}{2}mv^2$
- model qualitatively and quantitatively the trajectories of charged particles in electric fields and compare them with the trajectories of projectiles in a gravitational field
- analyse the interaction between charged particles and uniform magnetic fields, including:
  - acceleration, perpendicular to the field, of charged particles
  - the force on the charge $F = qv_{\perp}B = qvB\sin\theta$
- compare the interaction of charged particles moving in magnetic fields to:
  - the interaction of charged particles with electric fields
  - other examples of uniform circular motion

The Motor Effect

Inquiry question: Under what circumstances is a force produced on a current-carrying conductor in a magnetic field?

Students:

- investigate qualitatively and quantitatively the interaction between a current-carrying conductor and a uniform magnetic field $F = lI_{\perp}B = lIB\sin\theta$ to establish:
  - conditions under which the maximum force is produced
  - the relationship between the directions of the force, magnetic field strength and current
  - conditions under which no force is produced on the conductor
- conduct a quantitative investigation to demonstrate the interaction between two parallel current-carrying wires
- analyse the interaction between two parallel current-carrying wires $\frac{F}{l} = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{r}$ and determine the relationship between the International System of Units (SI) definition of an ampere and Newton's Third Law of Motion

Electromagnetic Induction

Inquiry question: How are electric and magnetic fields related?

Students:

- describe how magnetic flux can change, with reference to the relationship $\Phi = B_{\parallel}A = BA\cos\theta$ (ACSPH083,
- analyse qualitatively and quantitatively, with reference to energy transfers and transformations, examples of Faraday's Law and Lenz's Law $\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$, including but not limited to:
  - the generation of an electromotive force (emf) and evidence for Lenz's Law produced by the relative movement between a magnet, straight conductors, metal plates and solenoids
  - the generation of an emf produced by the relative movement or changes in current in one solenoid in the vicinity of another solenoid
- analyse quantitatively the operation of ideal transformers through the application of:
  - $\frac{V_{\text{p}}}{V_{\text{s}}} = \frac{N_{\text{p}}}{N_{\text{s}}}$
  - $V_{\text{p}}I_{\text{p}} = V_{\text{s}}I_{\text{s}}$
  -
- evaluate qualitatively the limitations of the ideal transformer model and the strategies used to improve transformer efficiency, including but not limited to:

  - incomplete flux linkage
  - resistive heat production and eddy currents
- analyse applications of step-up and step-down transformers, including but not limited to:
  - the distribution of energy using high-voltage transmission lines

Applications of the Motor Effect

Inquiry question: How has knowledge about the Motor Effect been applied to technological advances?

Students:

- investigate the operation of a simple DC motor to analyse:
  - the functions of its components
  - production of a torque $\tau = nIA_{\perp}B = nIAB\sin\theta$
  - effects of back emf
- analyse the operation of simple DC and AC generators and AC induction motors
- relate Lenz's Law to the law of conservation of energy and apply the law of conservation of energy to:
  - DC motors and
  - magnetic braking