PHYS 2212 Introductory Physics II Electricity and Magnetism: Electromagnetic induction

Electromagnetic induction is the process of producing an electromotive force across an electrical conductor in a changing magnetic field.

The most common method of electromagnetic induction is Faraday's law of induction, which states that the induced electromotive force (emf) in a circuit is equal to the negative of the time rate of change of the magnetic flux through the circuit.

$$\mathcal{E}=-\frac{\mathrm{d}\Phi}{\mathrm{d}t}$$

The magnetic flux is defined as the product of the magnetic field and the area over which it is applied.

$$\Phi=B\cdot A$$

The direction of the induced emf is given by Lenz's law, which states that the induced emf always produces a current that opposes the change in magnetic flux.

$$\mathcal{E} \propto -\frac{\mathrm{d}\Phi}{\mathrm{d}t}$$

The SI unit for emf is the volt (V), and the unit for magnetic flux is the weber (Wb).

One application of electromagnetic induction is the generation of electricity in power plants. In a coal-fired power plant, for example, the coal is burned to heat water, which produces steam. The steam then turns a turbine, which is connected to a generator. The generator contains coils of wire that rotate in a magnetic field, and as the coils rotate, they cut through the field, inducing an emf in the wire. This emf drives the current in the power plant's electrical grid.

Another application of electromagnetic induction is in the operation of electric motors. In an electric motor, the coils of wire rotate in a magnetic field, and the induced emf drives the current in the coils. The interaction of the current in the coils with the magnetic field produces a torque that turns the shaft of the motor.