Guide to: Faraday's law, Lenz rule

Applications: Generation of EMF by time-changing magnetic flux

Basic idea: Time-varying magnetic flux results in electric fields pushing charge around.
Three possibilities for this: a) loop area changes; b) magnetic field strength changes;
c) angle between magnetic field and loop area changes.

Derivations: 1) Case (a) can be derived from charge being pushed by the magnetic force and finding an equilibrium with electric force due to charge separation.

2) Cases (b,c) cannot be derived: the resulting EMF has no beginning and no end.

3) for rapid time variation: electromagnetic waves propagate in vacuum by time-varying magnetic field causing electric field and vice versa.

Equations: magnetic flux: $\Phi_B = \vec{B} \cdot \vec{A} = BA\cos\theta$ where θ is the angle between $\vec{B}$ and the normal to the area (direction of area vector $\vec{A}$).

Faraday's law: $\mathcal{E} = -\frac{d\Phi_B}{dt}$ where the minus sign is called Lenz rule and prevents runaway solutions: orientation of induced magnetic field created by the induced current: it opposes the change in Φ_B.
Rails separated by L, permeated by constant B (perpendicular), bar dragged across with speed v: $|\mathcal{E}| = BLv$ (derive this!). Understand that when a circuit loop is formed (current flowing) a force is needed to keep the bar moving at v, and mechanical power-in = electrical power-out (derive 21.14)

Problems: 21.1-29; 56-61.

Figure out what is the source of changing magnetic flux (a, b, c above);

Understand the direction associated with the flux through the loop area: is the flux increasing or decreasing? The induced magnetic field attempts to oppose this change, this is what defines the direction of the induced current in the loop (by the simple RH rule) from the direction of the induced magnetic field. This field can be supporting the external field or opposing it depending on whether the flux is decreasing or increasing. Figs 21.10 and 21.11 are illustrating this.