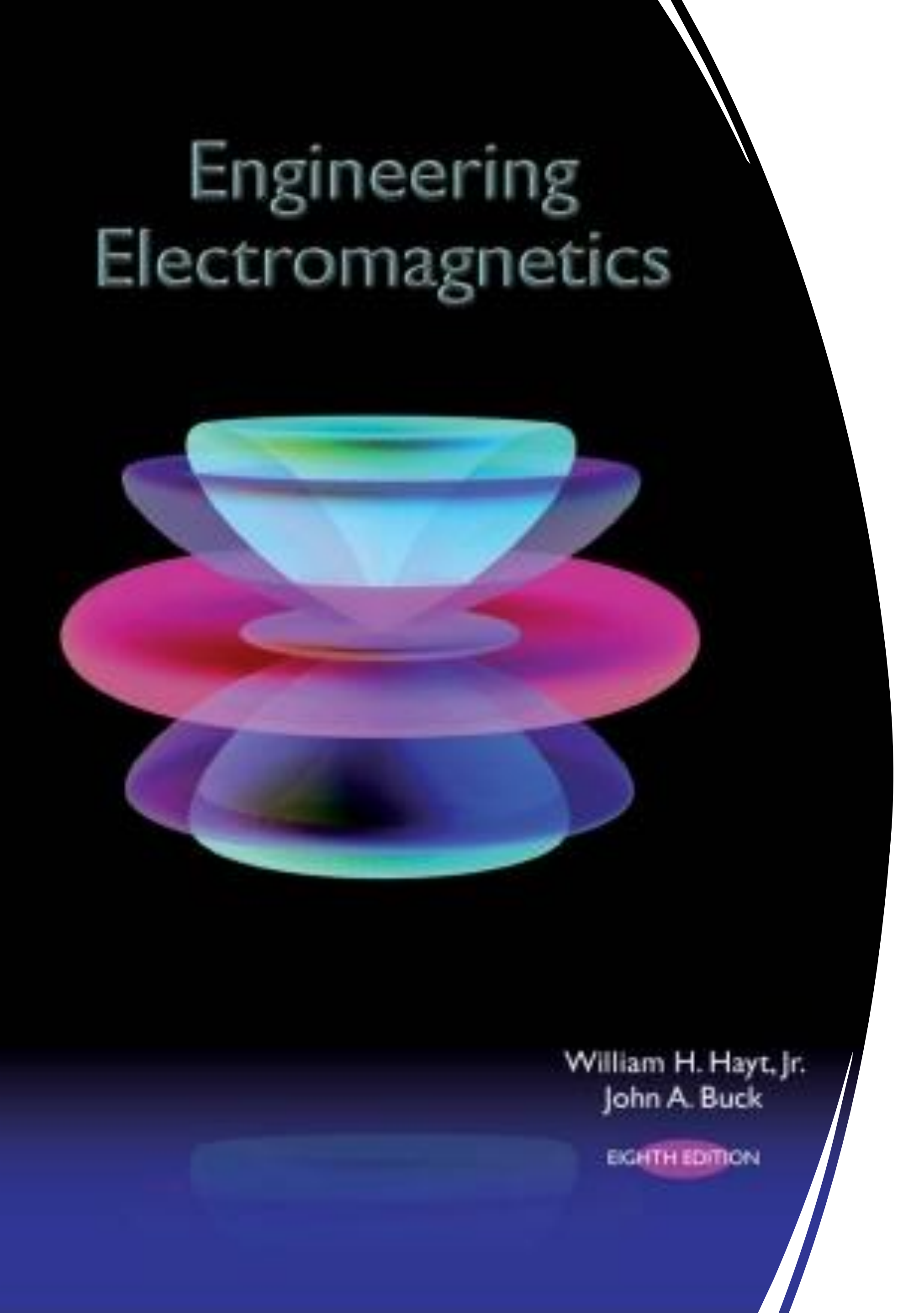


7. Time-Varying Fields and Maxwell's Equations

7.1 Faraday's Law

7.2 Displacement Current

7.3 Maxwell's Equations in Point Form

7.4 Maxwell's Equations in Integral Form

7.1 Faraday's Law

- An electromotive force (emf) is merely a voltage that arises from conductors moving in a magnetic field or from changing magnetic fields, and we shall define it in this section. Faraday's law is customarily stated as

$$\text{emf} = -\frac{d\Phi}{dt}\ \text{V}$$

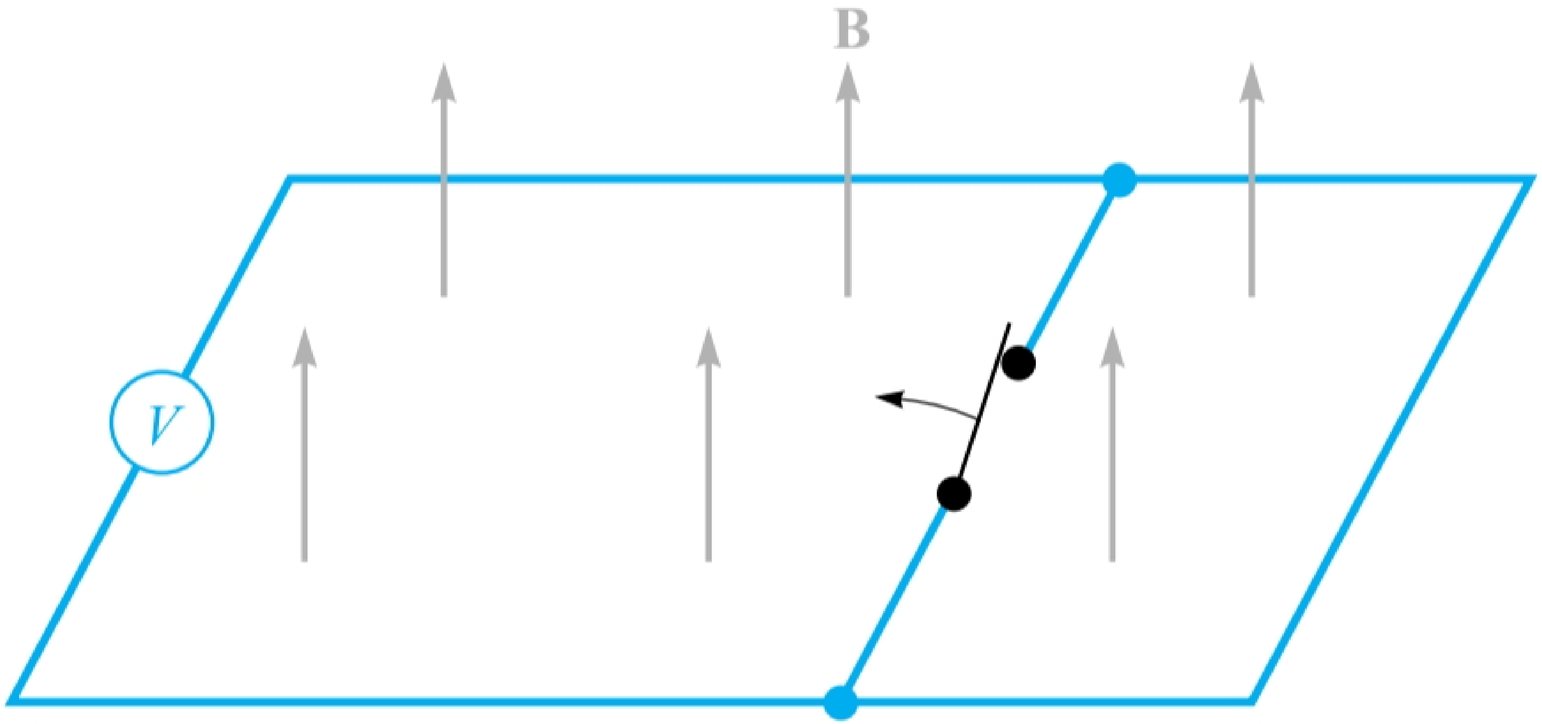
- If the closed path is that taken by an N-turn filamentary conductor, it is often sufficiently accurate to consider the turns as coincident and let

$$\text{emf} = -N\frac{d\Phi}{dt}$$

$$\int_S (\nabla \times \mathbf{E}) \cdot d\mathbf{S} = -\int_S \frac{\partial \mathbf{B}}{\partial t} \cdot d\mathbf{S}$$

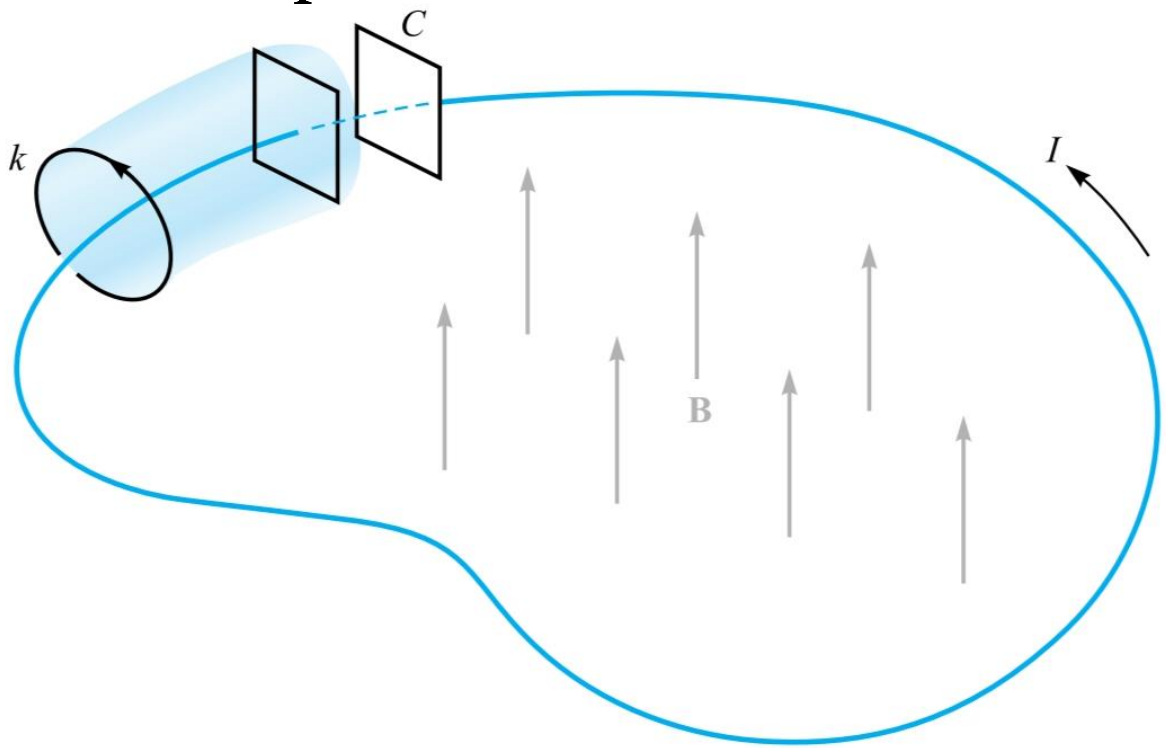
7.1 Faraday's Law

- An apparent increase in flux linkages does not lead to an induced voltage when one part of a circuit is simply substituted for another by opening the switch. No indication will be observed on the voltmeter.



7.2 Displacement Current

- A filamentary conductor forms a loop connecting the two plates of a parallel-plate capacitor. A time-varying magnetic field inside the closed path produces an emf of $V_0 \cos \omega t$ around the closed path. The conduction current / is equal to the displacement current between the capacitor plates.



7.3 Maxwell's Equations in Point Form

- non-time-varying

$$\nabla \cdot \mathbf{D} = \rho_v$$

$$\nabla \cdot \mathbf{B} = 0$$

- time-varying

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

$$\nabla \times \mathbf{H} = \mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}$$

7.3 Maxwell's Equations in Point Form

- The auxiliary equations relating **D** and **E**,

$$\mathbf{D} = \epsilon \mathbf{E}$$

- The auxiliary equations relating **B** and **H**,

$$\mathbf{B} = \mu \mathbf{H}$$

- defining conduction current density,

$$\mathbf{J} = \sigma \mathbf{E}$$

- and defining convection current density in terms of the volume charge density ρ_ν,

$$\mathbf{J} = \rho_\nu \mathbf{v}$$

7.4 Maxwell's Equations in Integral Form

- non-time-varying

$$\oint_S \mathbf{D} \cdot d\mathbf{S} = \int_{\mathrm{vol}} \rho_v dv$$

$$\oint_S \mathbf{B} \cdot d\mathbf{S} = 0$$

- time-varying

$$\oint \mathbf{E} \cdot d\mathbf{L} = -\int_S \frac{\partial \mathbf{B}}{\partial t} \cdot d\mathbf{S}$$

$$\oint \mathbf{H} \cdot d\mathbf{L} = I + \int_S \frac{\partial \mathbf{D}}{\partial t} \cdot d\mathbf{S}$$