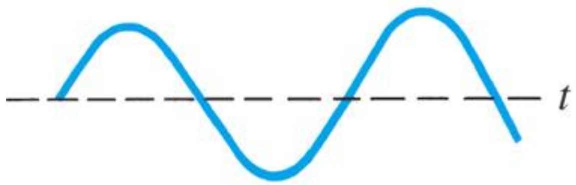
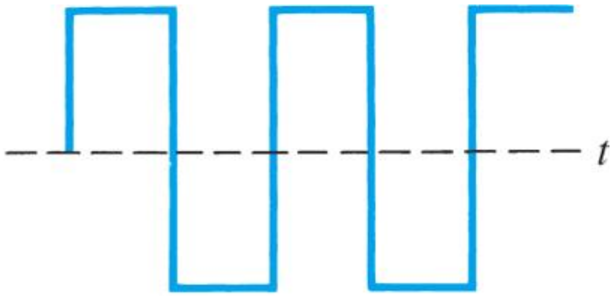
Lecture 26:Time-Varying Fields

Faraday's law, applications, Chapter 9, 399-410

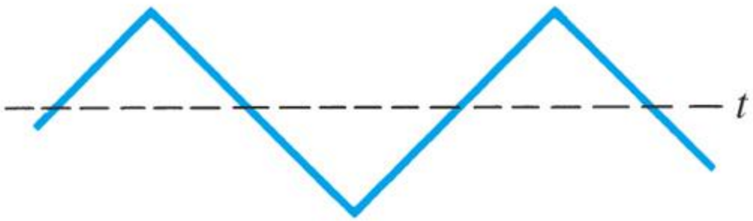
Examples of Time-Varying Fields



(a)

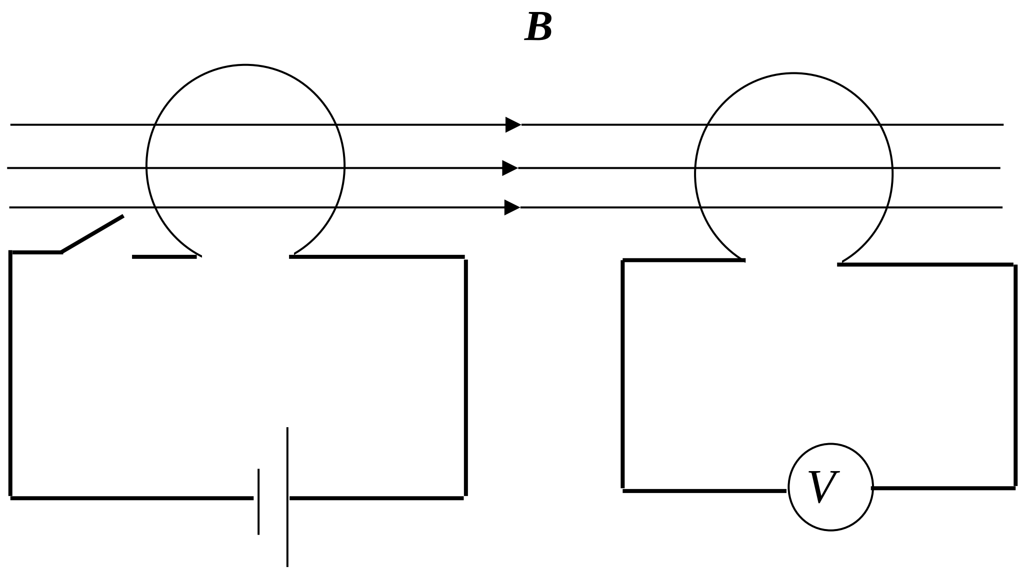


(b)



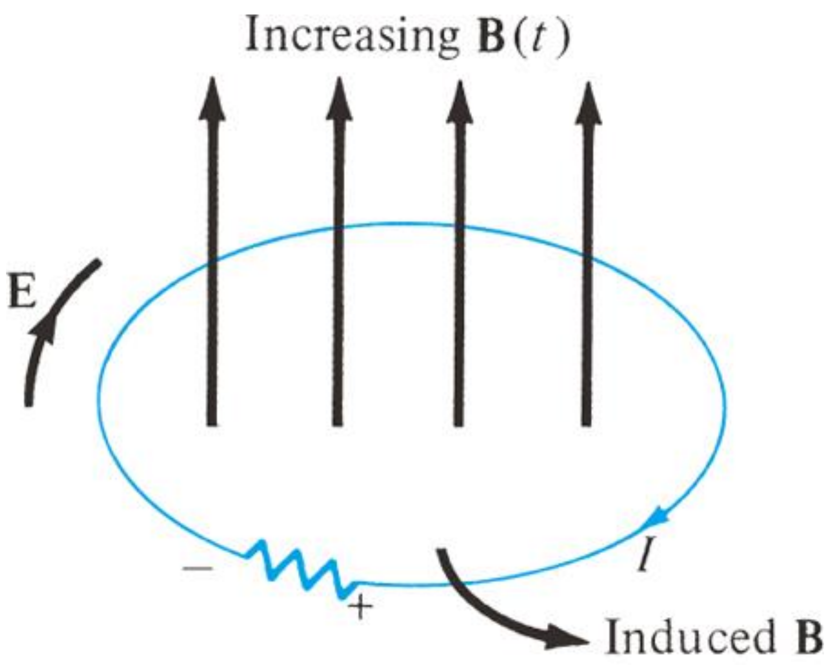
(c)

Faraday’s Experiment



when the switch is opened or closed the voltmeter gives a reading!

Faraday's Law



$$\text{EMF} = -\frac{d\lambda}{dt} = -N\frac{d\psi}{dt}$$

$$\psi = \iint_S \mathbf{B}.d\mathbf{S}$$

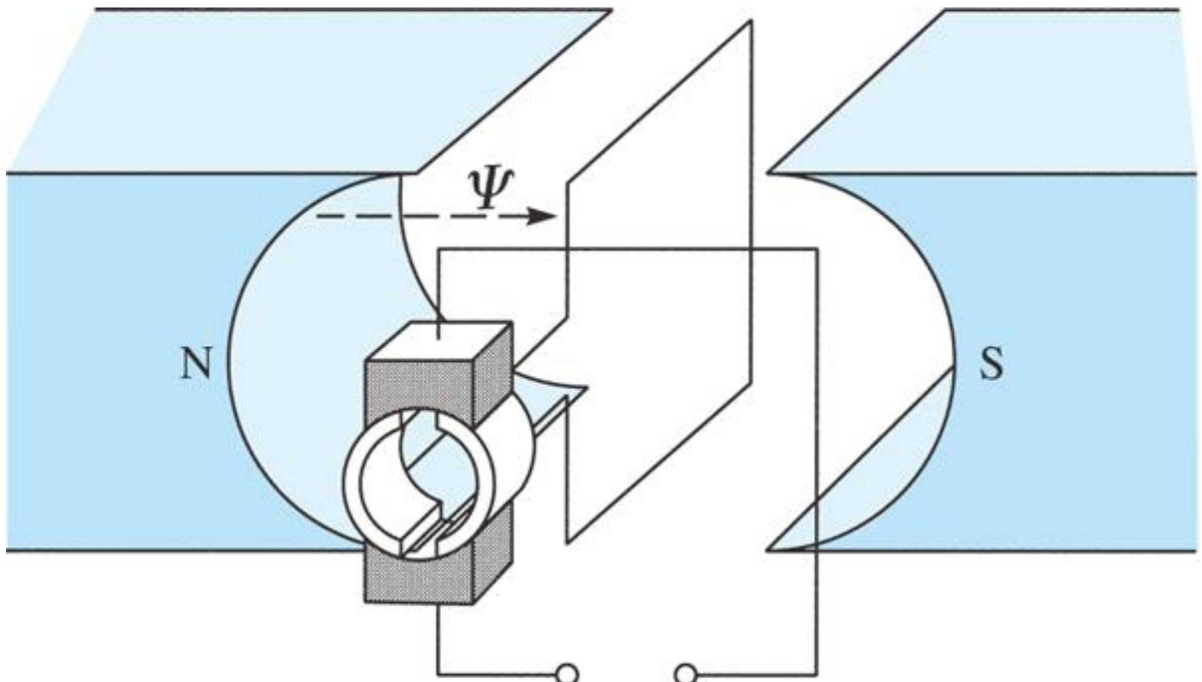
for a single turn

$$\oint \mathbf{E}.d\mathbf{l} = -\frac{\partial}{\partial t}\iint_S \mathbf{B}.d\mathbf{S}$$

applying Stoke's theorem $\nabla \times \mathbf{E} = -\dfrac{\partial \mathbf{B}}{\partial t}$

A time-varying magnetic field creates an electric field!

Electric Generator

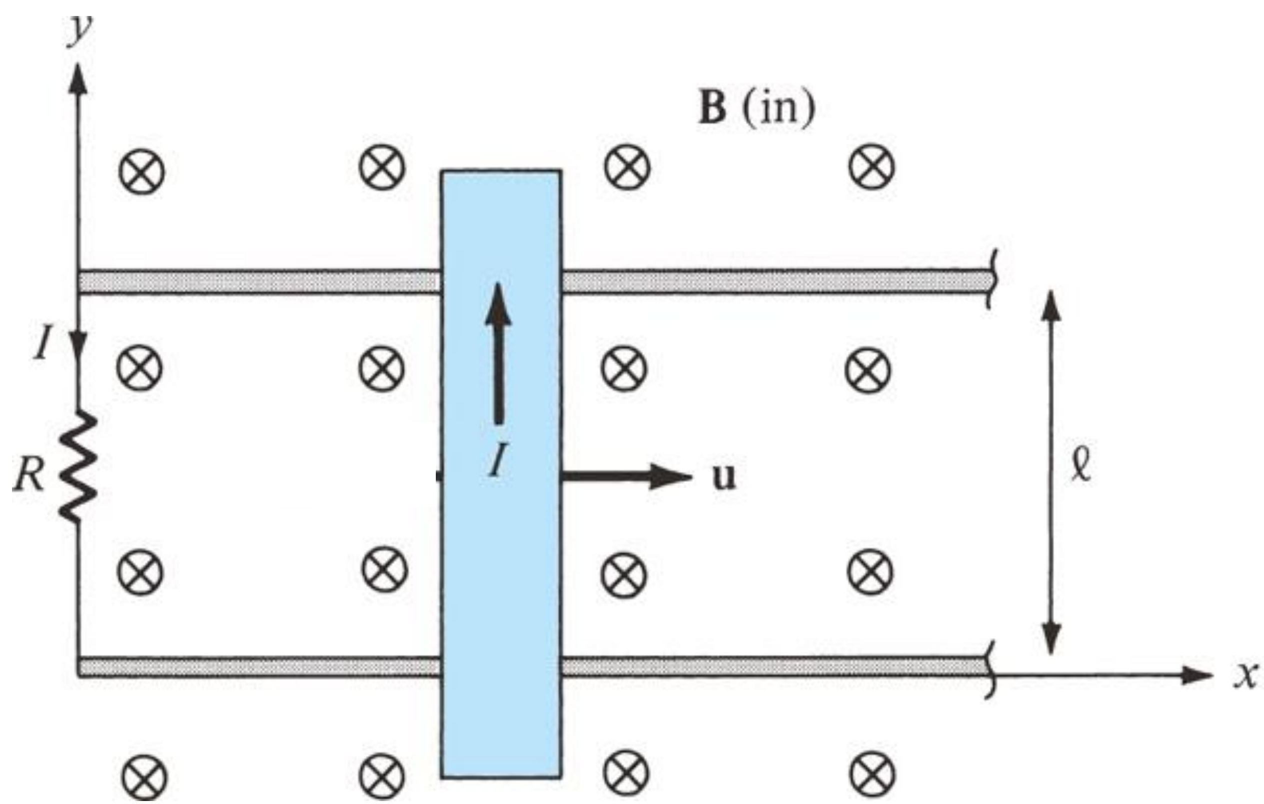


$$\psi = \iint \mathbf{B}.d\mathbf{S} = \iint B dS \cos(\theta)$$

$$\psi = \iint B dS \cos(\omega t) = \psi_o \cos(\omega t)$$

$$EMF = -\frac{d\psi}{dt} = \psi_o \omega \sin(\omega t)$$

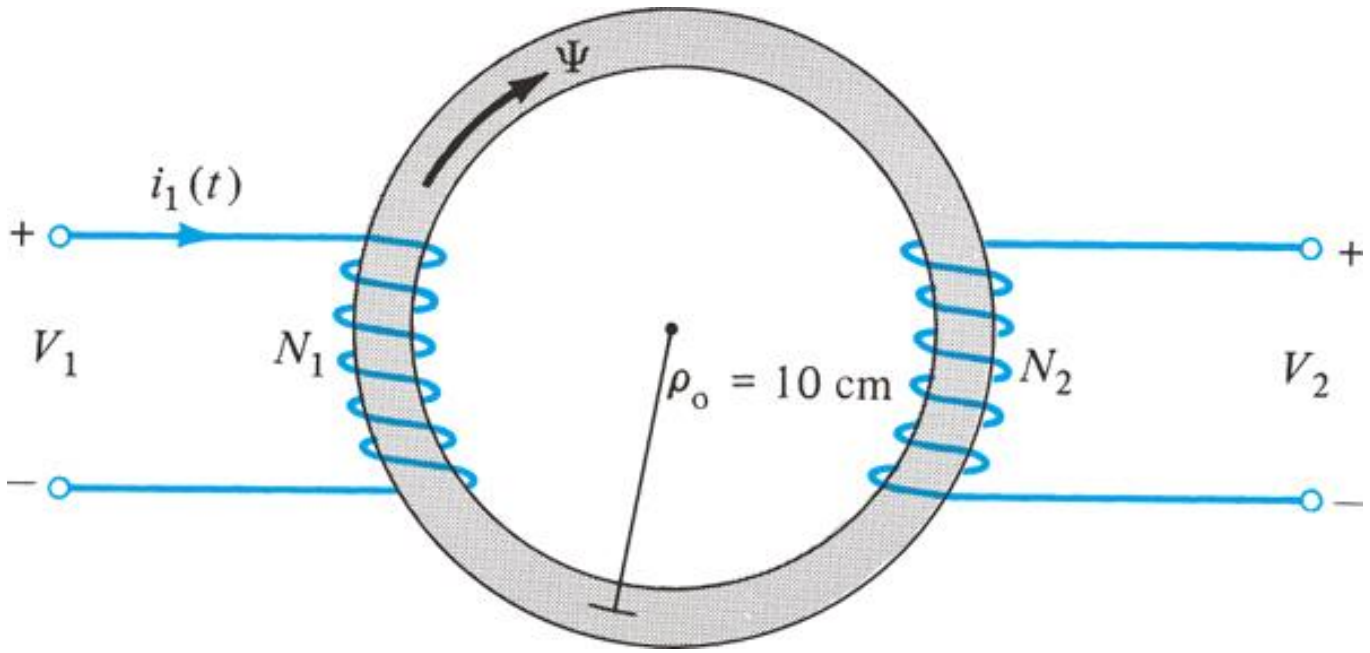
A Moving Loop



$$\mathbf{F}_m = q\mathbf{u}\times\mathbf{B} \Rightarrow \mathbf{E}_m = \mathbf{u}\times\mathbf{B}$$

$$\text{EMF} = \int \mathbf{E}.d\mathbf{l}$$

Transformers



$$V_2 = -\frac{d\lambda_{21}}{dt} = -N_2 \frac{d\psi_{21}}{dt}$$

$$V_2 = -N_2 \frac{d}{dt} \iint_{S2} \mathbf{B}_1 . d\mathbf{S}$$