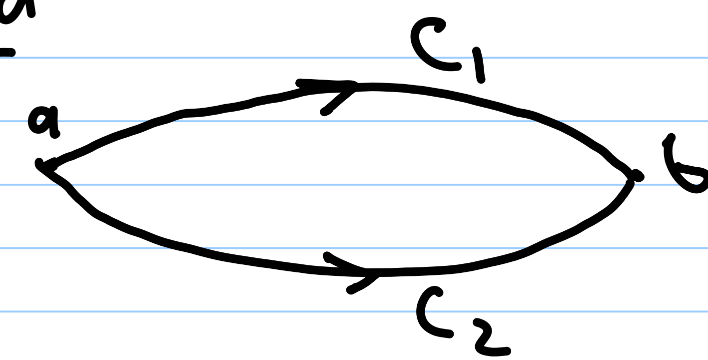
Lecture 8

From Sections 9.1 – 9.4

Solve 9.1 – 9.16

<u>Static Electric Field</u>



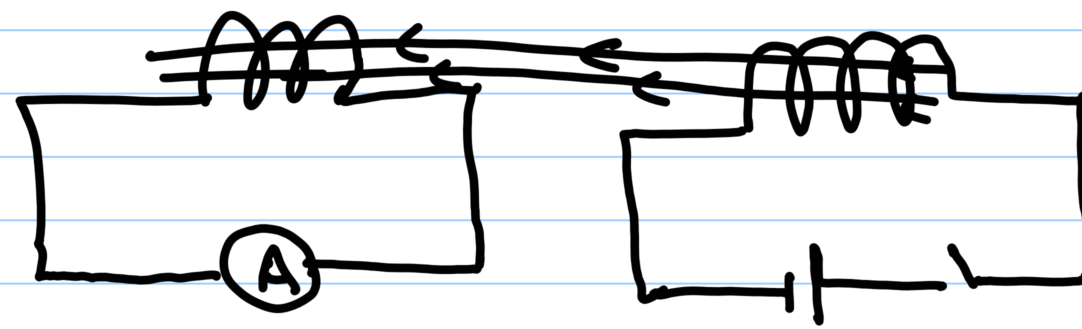
$$V_a - V_b = -\int_b^a \underline{E} \cdot d\underline{l}$$

$$V_a - V_b = \int_a^b \underline{E} \cdot d\underline{l} = \int_{C_1} \underline{E} \cdot d\underline{l} = \int_{C_2} \underline{E} \cdot d\underline{l}$$

$$\oint \underline{E} \cdot d\underline{l} = 0 \Rightarrow \iint_S (\nabla \times \underline{E}) \cdot d\underline{s} = 0$$

$\nabla \times \underline{E} = \underline{0}$ for electrostatics

Faraday's Law



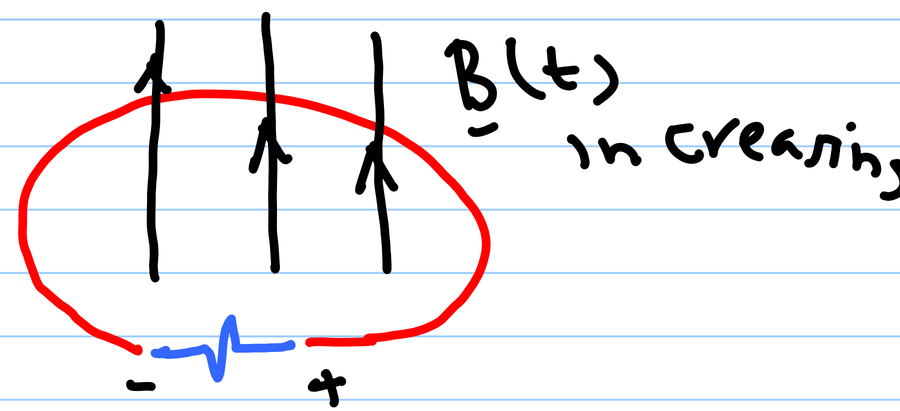
* In this experiment, the ameter gives a reading only at the moment when switch is closed or opened
* Time varying magnetic field gives rise to an electric field!

Faraday's Law (Cont'd)

$$\oint \underline{E} \cdot \underline{dl} = -\frac{d}{dt}\left[\iint_S \underline{B} \cdot \underline{ds}\right]$$

$$emf = -\frac{d}{dt}\Psi_m$$

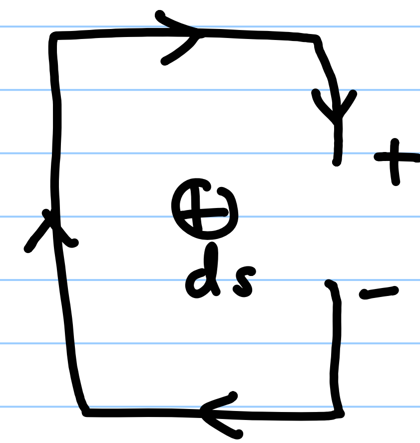
* The emf polarity opposes the change in the magnetic flux !



Point Form of Faraday's Law

$$\oint \underline{E} \cdot d\underline{l} = -\frac{d}{dt} \iint_S \underline{B} \cdot d\underline{s}$$

$$\oint \underline{E} \cdot d\underline{l} = -\iint_S \frac{d\underline{B}}{dt} \cdot d\underline{s} \quad (S \text{ is const})$$



$$\iint_S (\nabla \times \underline{E}) \cdot d\underline{s} = -\iint_S \frac{d\underline{B}}{dt} \cdot d\underline{s}$$

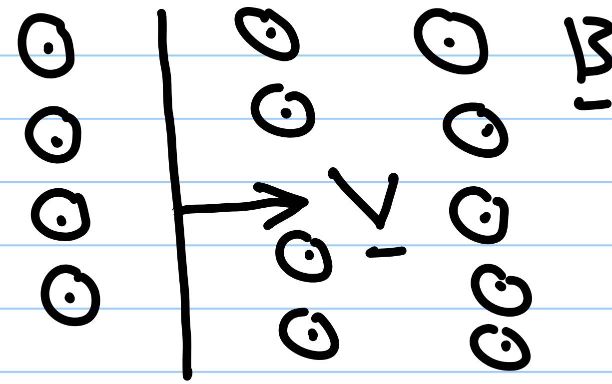
$$\nabla \times \underline{E} = -\frac{\partial \underline{B}}{\partial t}$$

Time varying magnetic field generates a space varying electric field!

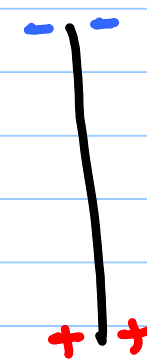
Motional EMF

$\underline{F} = Q\,\underline{V} \times \underline{B}$

$\underline{E}_m = \frac{\underline{F}}{Q} = \underline{V} \times \underline{B}$



$V_{emf,m} = \int \underline{E} \cdot \underline{dl}$ on moving parts

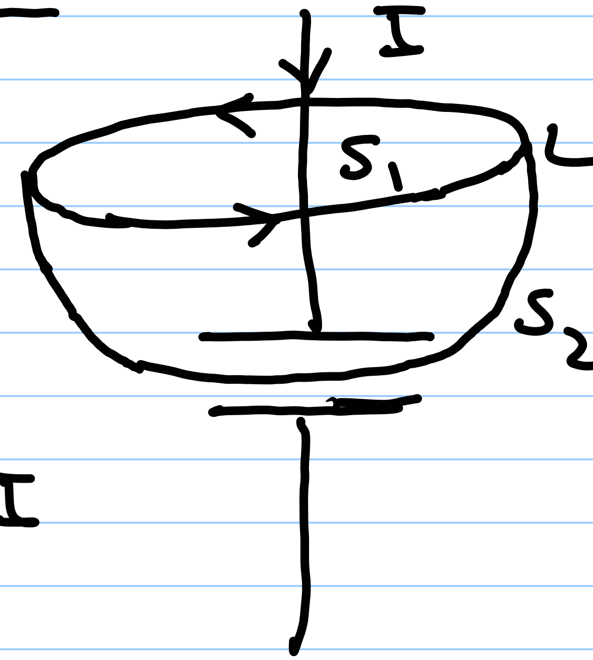


* For the general Case

$$V_{emf} = -\iint_S \frac{\partial \underline{B}}{\partial t} \cdot \underline{ds} + \oint (\underline{V} \times \underline{B}) \cdot \underline{dl}$$

Ampère's Modified Law

* Original Ampère's Law is not complete



* over S_1

$$\oint_L \underline{H} \cdot d\underline{l} = \iint_{S_1} \underline{J} \cdot d\underline{s} = I$$

* over S_2

$$\oint_L \underline{H} \cdot d\underline{l} = 0$$

Current in capacitor is not due to flow of charges!

Ampère's Law (cont'd)

$$\oint \underline{H} \cdot d\underline{l} = \iint_s \left(\underline{J} + \frac{\partial \underline{D}}{\partial t}\right) \cdot d\underline{s}$$

$$\oint \underline{H} \cdot d\underline{l} = \iint_s \underline{J} \cdot d\underline{s} + \iint_s \frac{\partial \underline{D}}{\partial t} \cdot d\underline{s}$$

$$\oint \underline{H} \cdot d\underline{l} = I_c + I_D$$

Conduction current | displacement current

* In good Conductors $I_c \gg I_D$

Point Form of Ampère's law

$$\oint \underline{H} \cdot \underline{dl} = \iint_s \underline{J} \cdot \underline{ds} + \iint_s \frac{\partial \underline{D}}{\partial t} \cdot \underline{ds}$$

$$\iint_s (\nabla \times \underline{H}) \cdot \underline{ds} = \iint_s \underline{J} \cdot \underline{ds} + \iint_s \frac{\partial \underline{D}}{\partial t} \cdot \underline{ds}$$

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

Time varying electric field gives rise to space varying magnetic field