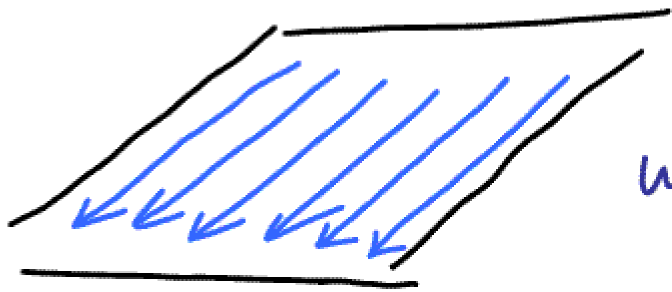
Physics 114 - March 28, 2006

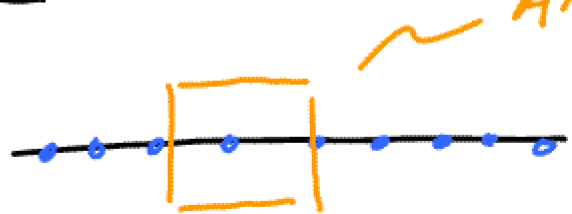
project info on web

Last Time:



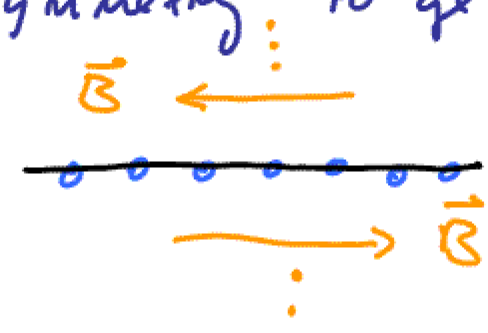
∞ current sheet with linear uniform current density j

Amperian loop



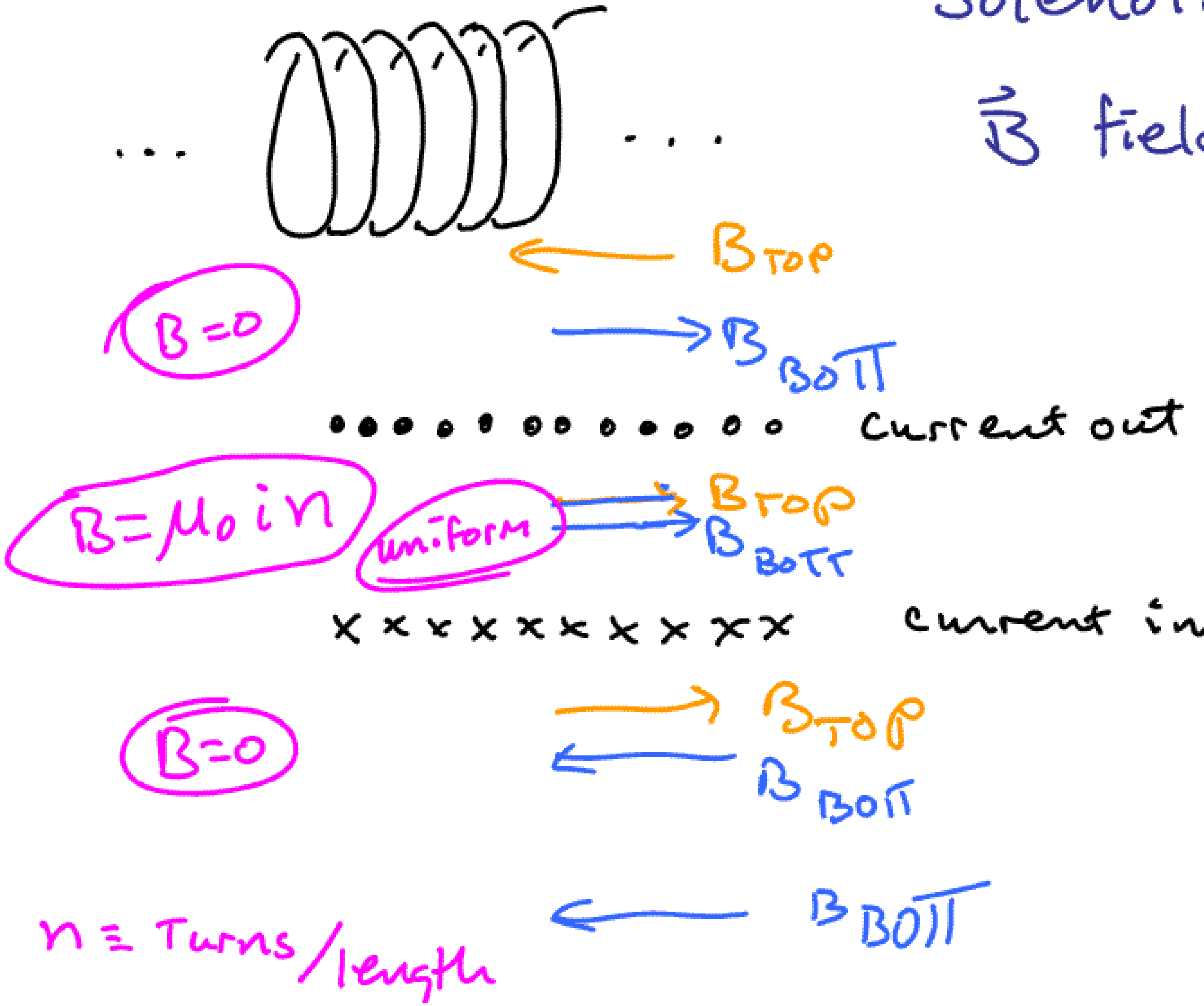
use Amperes' Law + Symmetry to get

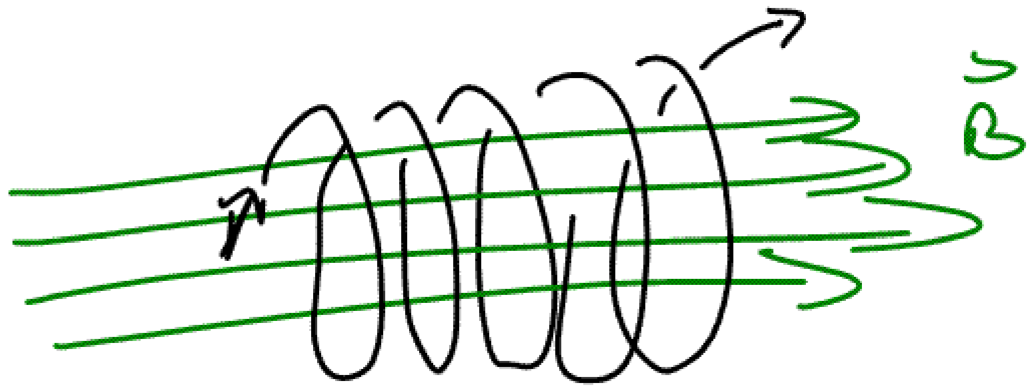
$$|B| = \frac{\mu_0 j}{2}$$



$\vec{B}$ uniform + ∞

Infinite Solenoid $\vec{B}$ field

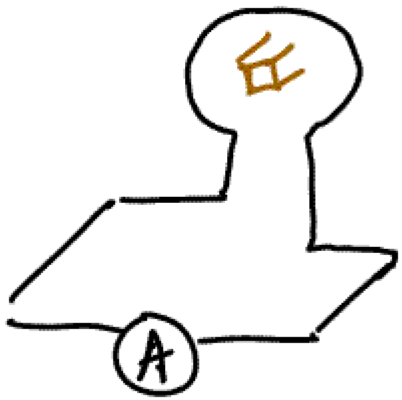




Seduce vs. Induce

Magnetic Induction

1830's Michael Faraday
Joseph Henry



Induction: A changing magnetic field induces an EMF (a changing electric field)

No changing fields
Magnetostatics

Kirchoff

$$\sum V \Big|_{\text{closed loop}} = 0$$

$$E \sim -\frac{dV}{dx}$$

$$E \cdot dl \sim V$$

$$\oint \vec{E} \cdot \vec{dl} = 0$$

Kirchoff in free space

changing fields

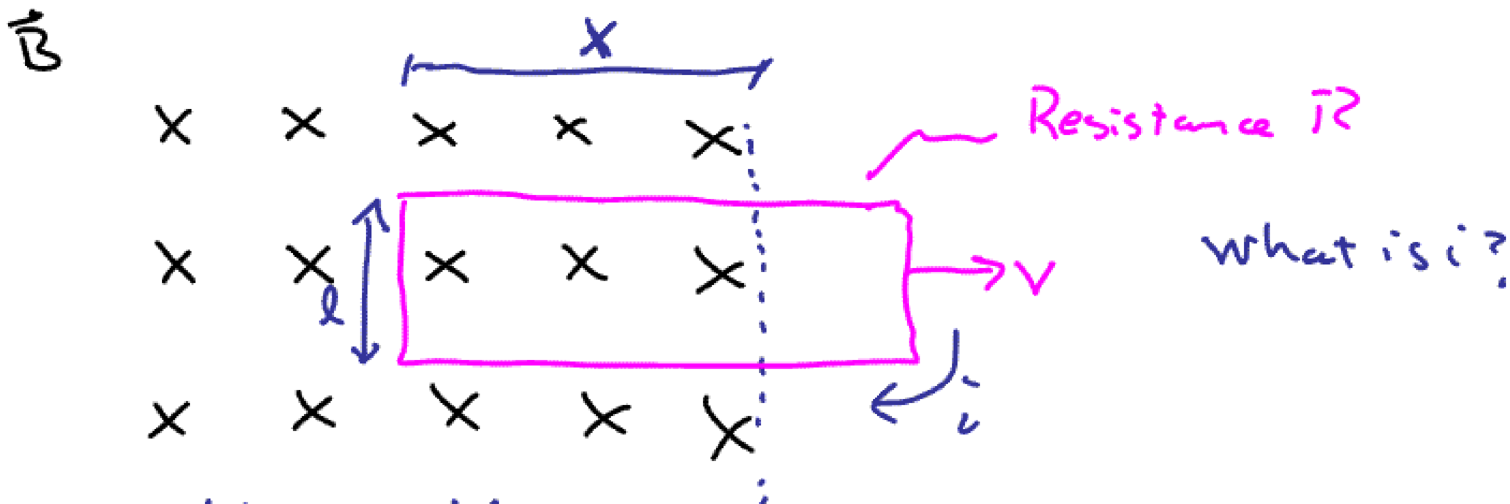
$$\mathcal{E} = \oint \vec{E} \cdot \vec{dl} = -\frac{d\Phi_M}{dt}$$

$$\Phi_M = \int_{surf} \vec{B} \cdot \vec{dA}$$

Faraday's Law

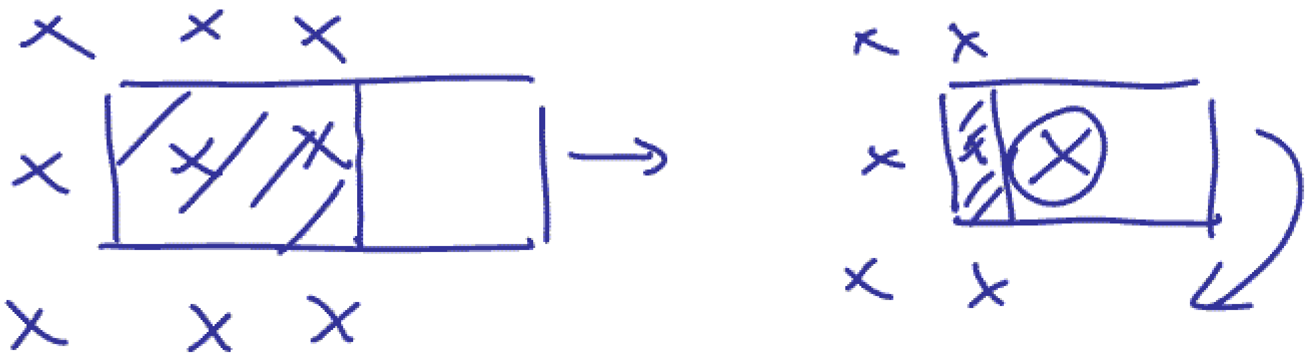
True in Wires
Materials
Free space

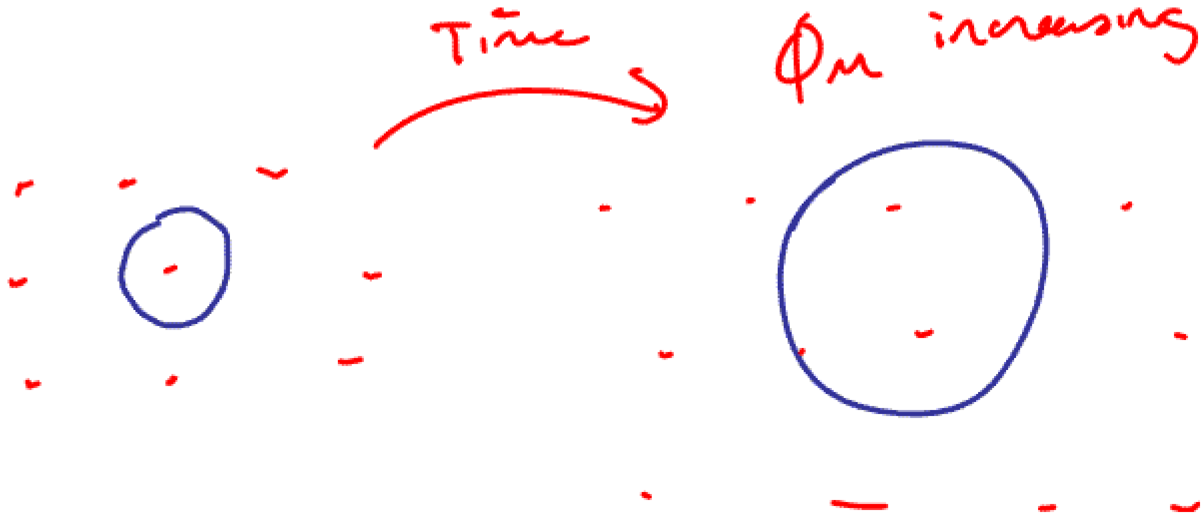
Lenz's Law – The induced current opposes the change that produced it.

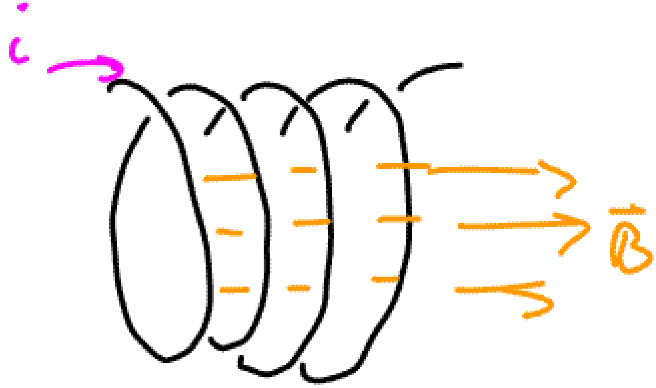


$$\mathcal{E} = -\frac{d\phi_M}{dt} = -\frac{d(Blx)}{dt} = -Bl\frac{dx}{dt} = -Blv$$

$$|i| = \mathcal{E}/R = Blv/R$$




Time
Φ_M increasing



$$|\vec{B}| = \mu_0 n i$$

n = # Turns / length

single loop

$$\phi_m = BA$$

↑ x sect. area

$$\phi_m = (\mu_0 n i) A \qquad \phi_m \propto i$$

prop. constant depends on geometry

length l of solenoid

$$\# \text{loops} = n l$$

$$\Phi_M = (\mu_0 n i A) n \ell$$

length ℓ

$$= [\mu_0 n^2 A \ell] i$$

↑ geometry

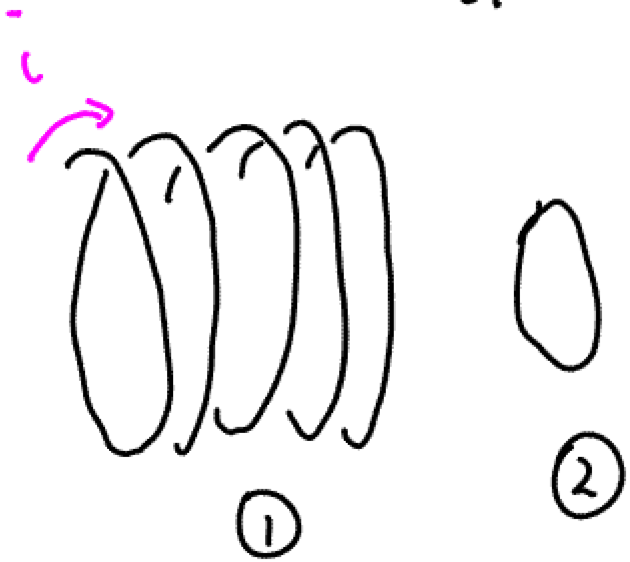
$$\Phi_M = L i$$

↑ const of prop

$\equiv$ const of self inductance

$$\Delta i \rightarrow \frac{di}{dt} \rightarrow \frac{d\Phi_M}{dt} \rightarrow \mathcal{E}$$

$$\mathcal{E} = -\frac{d\Phi_M}{dt} = -L\frac{di}{dt}$$



Δi in ①

ΔB in ②

induces $\mathcal{E}$ in ②

$\phi_{②} \propto i_{①}$

$\phi_{②} = L\, i_{①}$

↑

= const of Mutual inductance

$$\mathcal{E}_2 = -L\frac{di_1}{dt}$$