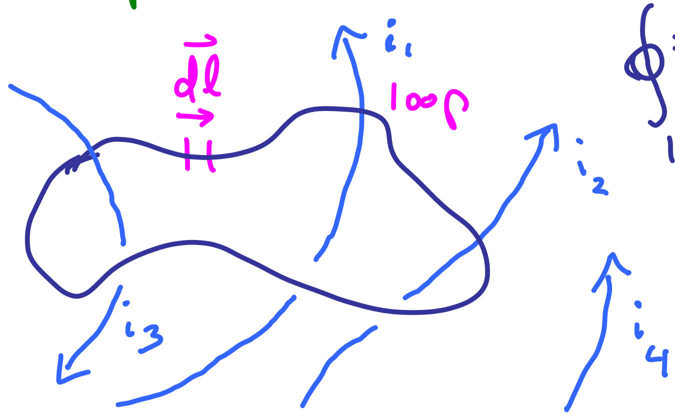
P114 - March 24, 2015

- 2 weeks exam 2 grading (TA Exams)
- Today - My office hours 3-4
- Prob set due a week from Friday

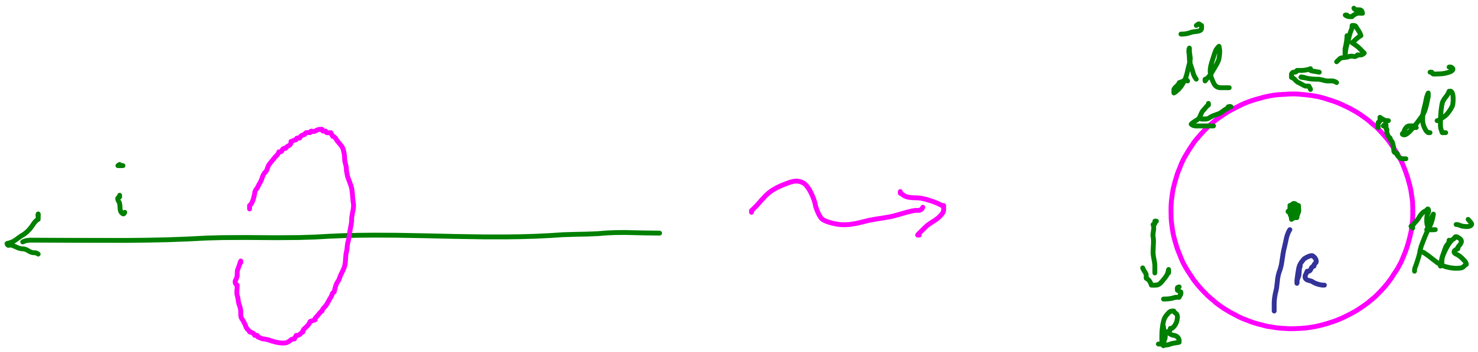
  LONG don't put it off until next week

Ampere's law



$$\oint_{loop} \vec{B}\cdot d\vec{l} = \mu_0 I_{encl}$$

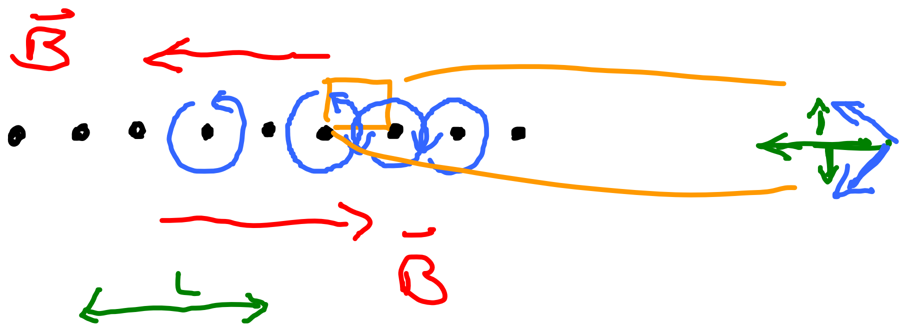
useful for calc $\vec{B}$ under circumstances w/ proper symmetry

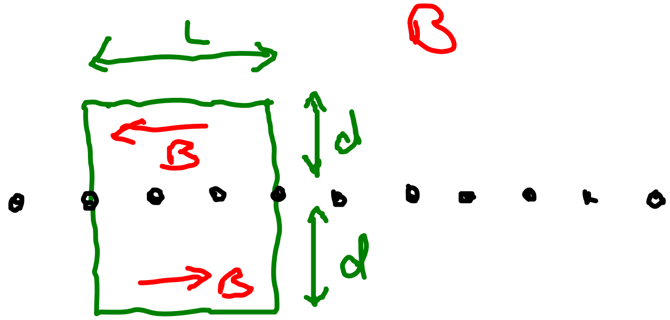


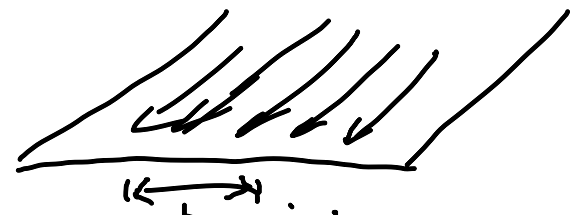
$$\int \vec{B}\cdot d\vec{l} =$$

$$B\int_0^{2\pi R} dl$$

$$B\,2\pi R = \mu_0 i$$



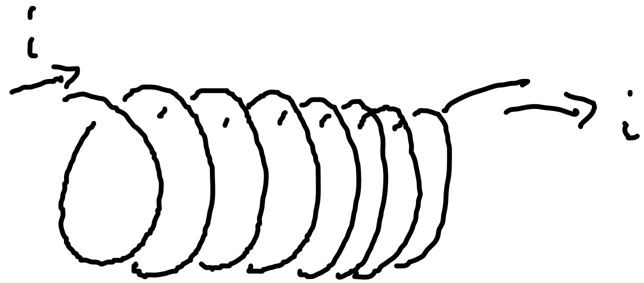


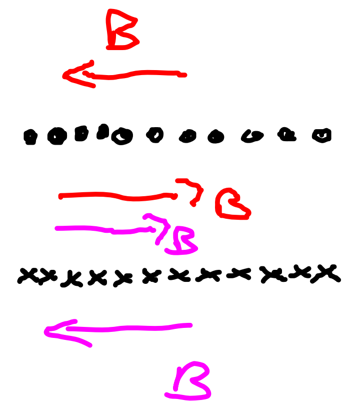


$I = jL$

$$\oint \vec{B}\cdot d\vec{l} = 2BL = \mu_0 j L \qquad |\vec{B}| = \frac{\mu_0 j}{2}$$

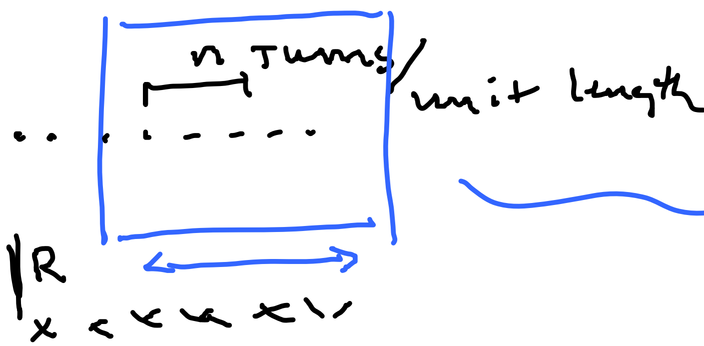
Solenoid





∞ Solenoid

long, rigid slinky or spring



$I_{encl} = Lin$

$$\oint \vec{B} \cdot d\vec{l} = BL = \mu_0 L i n$$

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

B field inside ∞ solenoid

outside B = 0

Seduce vs. induce

~~Seduction~~

Induction

A changing magnetic field induces an EMF

Michael Faraday
(1791–1867)

British physicist
+
chemist

Discovered
Magnetic induction

Farad named
after Faraday

Also invented the
Bunsen Burner

No changing fields
Magnetostatic

Kirchoff

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

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

$$E \cdot dl \sim V$$

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

Changing fields

$$\mathcal{E} = \oint_{\text{closed loop}} \vec{E} \cdot \vec{dl} = -\frac{d\Phi_m}{dt}$$

($\mathcal{E}$: induced EMF)

Faraday's law of induction

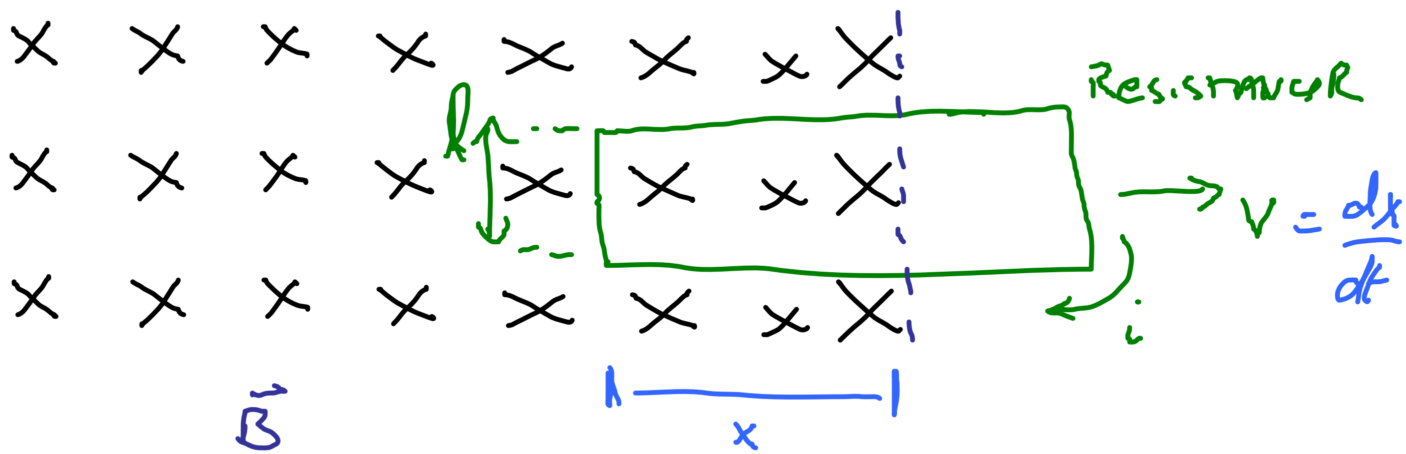
- Wires
- Free space
- Materials

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

↑ induced EMF

closed loop

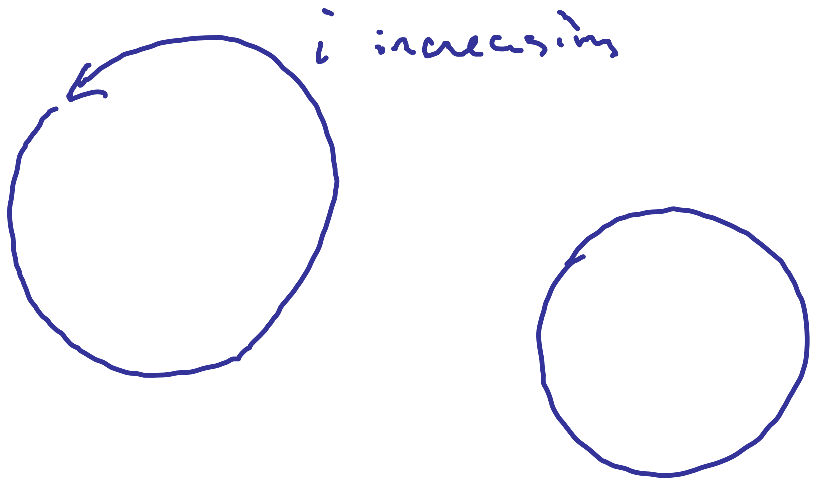
Lenz's Law – The induced EMF ("current") opposes the change that produces it



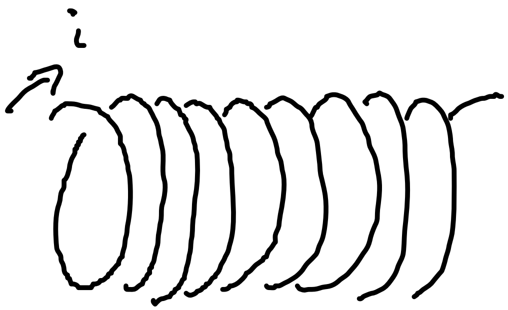
$$\mathcal{E} = -\frac{d\Phi_M}{dt} = -\frac{d(Blx)}{dt} = -Bl\frac{dx}{dt} = -Blv$$

$$\vec{F} = -k(\vec{x} - x_0)$$

$$\mathcal{E} = iR \qquad |i| = \frac{\mathcal{E}}{R} = \frac{Blv}{R}$$


i increasing

inductor without a date



Solenoid inductor

$\phi_m \propto i$

$\phi_M = BA$

single loop $\phi_M = (\mu_0 n i)A$

length of solenoid $= \ell$

loops $= n\ell$

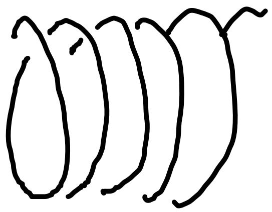
$\phi_{M_{\text{length } \ell}} = (\mu_0 n i A) n\ell$

$\phi_{M_{\text{length } \ell}} = (\mu_0 n^2 A \ell)\, i$

$\equiv L =$ constant of self inductance

$$\frac{di}{dt} \rightarrow \frac{d\Phi_m}{dt} \rightarrow \varepsilon$$

$$\varepsilon = -\frac{d\Phi_m}{dt} = -L\frac{di}{dt}$$



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