Faraday's Law and Lenz's Law

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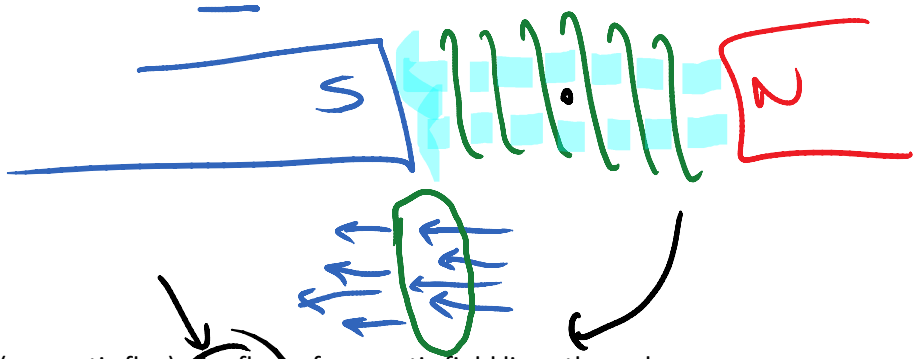
12:36 PM

Generating Electricity:

loops of wire

This requires a changing magnetic field around a conductor. You can move the conductor in the magnetic field, or you can move the magnetic field or you can strengthen/weaken the magnetic field.

Most commonly we rotate the conductor in the B field.



Flux (magnetic flux): the flow of magnetic field lines through an area

$\phi = BA$

ϕ = flux, B = mag field, A = surface area

$Wb = T \cdot m^2$

When you break webers ← you generate Voltage

Faraday's Law: An EMF (voltage) is generated any time a flux is changed. The faster you change the flux The greater the EMF produced.

$$\mathcal{E} = -n\frac{\Delta\phi}{\Delta t}$$

n = # of loops or turns in a solenoid
$\Delta\phi$ change in flux
Δt change in time

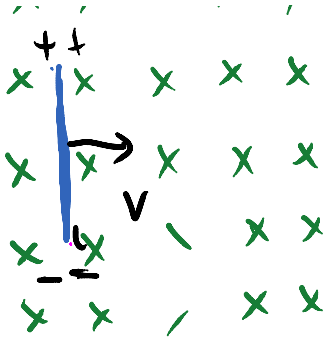
Lenz's Law ← allows us to conserve energy
without the (−) Faraday's Law would produce infinite energy

Whatever Fb is created must oppose the $\Delta\Phi$ in order to conserve energy. Otherwise you will get infinite energy out.
Faraday's Law for a linear conductor:

$\mathcal{E} = Blv$ ← velocity
l = length of conductor

$\varepsilon = BlV$ ← velocity

length of conductor



For linear conductors, which end becomes positive?

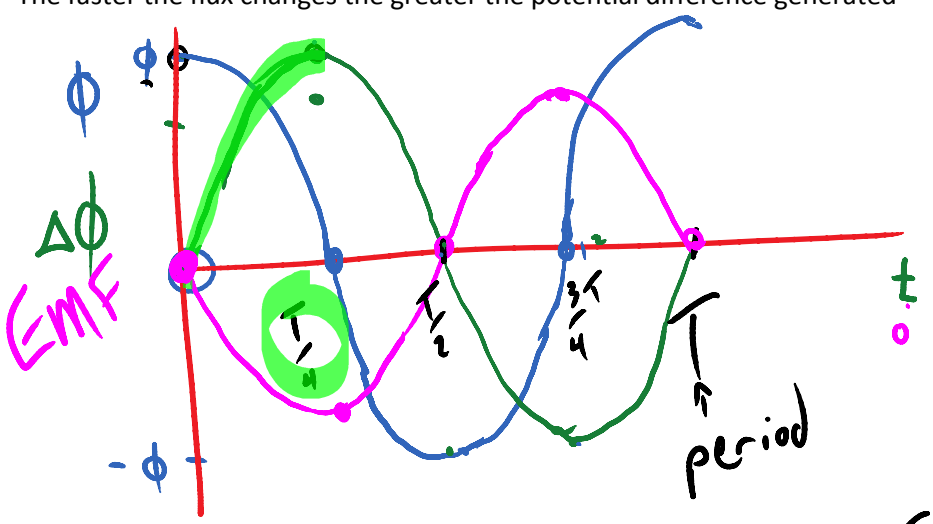
RH motor Rule

think about the protons in conductor

higher frequency gives more Emf

The faster the flux changes the greater the potential difference generated

$$\varepsilon = -n\frac{\Delta\phi}{\Delta t}$$



Emf max (−) when ΔΦ max

Emf is max when ϕ_{min}

Emf is a maximum when ΔΦ is a maximum

ΔΦ is a maximum when Φ is a minimum

$\frac{n}{2} \rightarrow 2n$ on p. n, n^2, n^3 $n=2$

4,5 p 252

1,2 p 256

$$\varepsilon = -\frac{n\Delta\phi \times 4}{T}$$ in terms of f

$$\varepsilon = -4n\Delta\phi f$$

magnets → coils

Lenz's Law: this is the negative in Faraday's Law it states that the induced Emf must oppose the change in flux that created it.

$\frac{\Delta\phi}{\Delta t}$

the induced Emf will cause current to flow that opposes

Generator frequency: the faster an armature rotates the smaller Δt is and larger the Emf generated. This means the armature has higher frequency and Δt could replaced with

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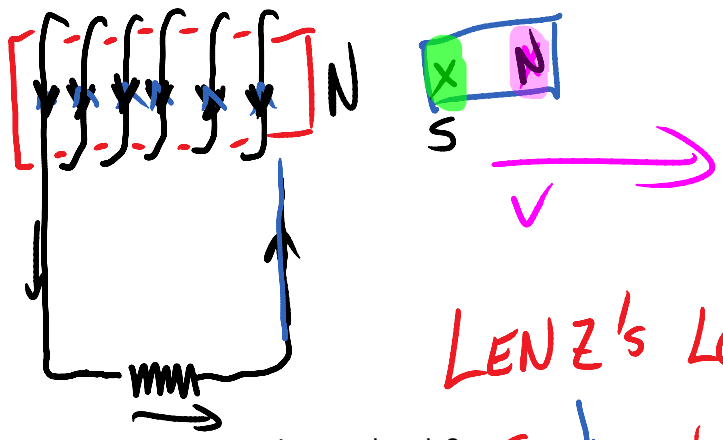
Current caused by induced emf through resistor from B to A

mag the change

Δt ↓ ¼ ↑ BA to 0 A

The main effect of Lenz's Law is that any induced (created) EMF by changing a magnetic flux will cause a current to flow that opposes the initial change.

Determine the pole labelled X in the magnet below:



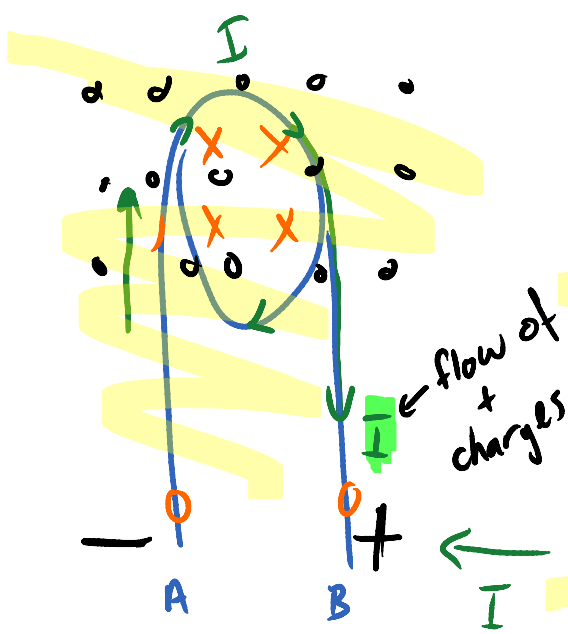
LENZ's Law

$\mathcal{E} = -n\frac{\Delta\phi}{\Delta t}$

What is the solenoid' s response to an oncoming south pole?

What direction is the current through the resistor?

Emf produce in turns of solenoid will be OPPOSITE to Δϕ that creates it.



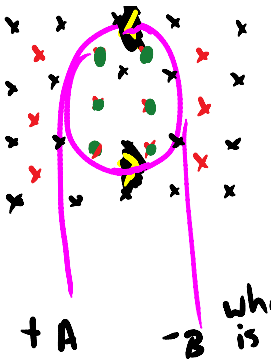
Reverse B

flow of + charges

What is the response of the solenoid? ← will create a mag field to be like original

Which side is +

B = 0.40T If the change ΔB A (.08-.04)



which side is +?

$B_o = .040T$

$B_f = .080T$

If the change in B occured in 0.50s, there are 100 turns of radius 2.0cm find the Emf between A and B

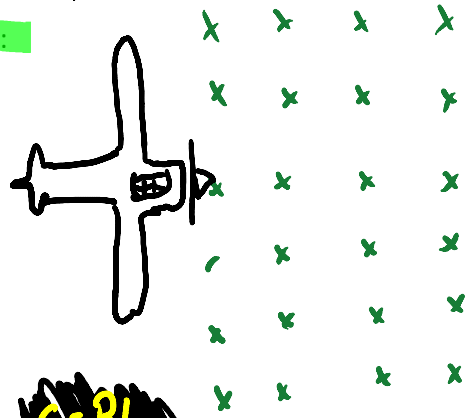
$\mathcal{E} = \frac{-n\Delta\phi}{\Delta t}$ ($\Delta B\, A$, $B\,\Delta A$)

$\mathcal{E} = \frac{-100\,\Delta B\,\pi(.02)^2}{.50}$ $(.08 - .04)$

$= -0.010V$

The EMF in a Linear Conductor:

$$\mathcal{E} = \frac{-n\Delta\phi}{\Delta t}$$



Wing span = 60 m

$B = 5.0 \times 10^{-4}$ T

find the Emf induced between wing tips at $v = 200$ m/s

$\mathcal{E} = Blv$

$5 \times 10^{-4}(60)200 = 6.0V$

$\mathcal{E} = Blv$ ← + particles will feel a force according to the RH Motor Rule

Three ways to induce EMF

1) Change the magnetic field ($\Delta\Phi \propto \Delta B$)
2) Rotate a coil or magnet ($\Delta\Phi \propto \Delta A$)
3) Change the shape of the coil