Chapter 20 Electromagnetic Induction and Waves

20.1 Induced emf: Faradays law and lenz's law

-we observe that, when a magnet is moved near a conducting loop, a current is induced. when the motion stops, the current stops

- magnet moved toward loop → more lines through the loop, sensing a change, a stronger magnetic field, produce a current which makes a magnetic field that tries to oppose the magnet coming near the loop

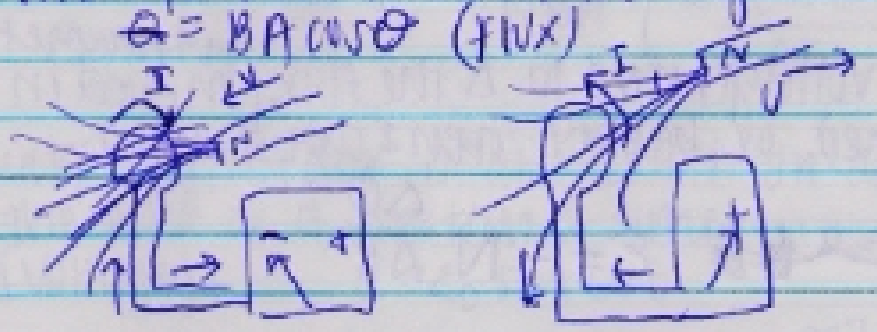
critical short answer

# of lines changing = flux is changing, current is produced

- currents change from + to - when direction is Δ

-When you start to curve, the fingers are the current.

$\Phi = BA\cos\theta$ (flux)



-on the other hand, when a loop move parallel to a magnetic field, no current is induced

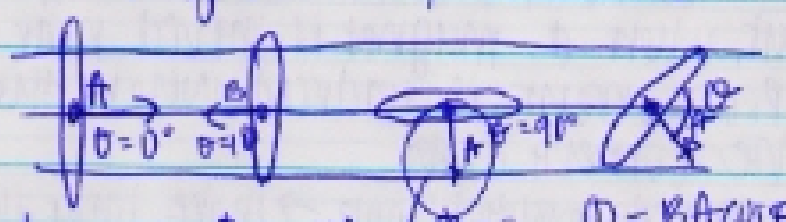
-an induced emf is produced in a loop or complete circuit whenever the number of magnetic field lines passing through the plane of the loop or circuit changes.

-changing current in one loop can induce a current in a 2nd loop

granite counter tops and radon = more radiation

- measure the change in the magnetic field through a loop $\Phi = BA\cos\theta$

magnetic flux, weber Wb



$\Phi = +BA$ $\Phi = -BA$ $\Phi = 0$ $\Phi = BA\cos\theta$

flux is max. max in neg.

always perpendicular to the loop

Faraday's law for induced emf

↳ the minus sign indicates the direction of the induced emf, which is given by Lenz's law.

want a voltage, need to Δ the flux. (move magnet in closer or further or battery - open & close switch.

$\mathcal{E} = -N\frac{\Delta\Phi}{\Delta t}$

Len's law: an induced emf in a wire loop or coil has a direction such that the current it creates produces its own magnetic field that opposes the change in magnetic flux through that loop or coil

↳ if the magnetic field is increasing, the induced current will produce a field in the opposite direction, tending to decrease the field

- direction of induced current given by right-hand rule

↳ thumb of right hand pointing in field, and fingers curled in direction of current

- now have loops and inductors

- lenz's law is a consequence of conservation of energy
  - the induced current is such that the flux through the loop tends to remain constant.

20.2 Electric Generators and Back emf.

- one way of changing the flux through a loop is to change its orientation w/ respect to the field. If this is done via some mechanical means, electricity can be generated.
  - constant changing voltage
    - Δ opening = Δ in flux

the induced emf is then

$$\mathcal{E} = -N\frac{\Delta\Phi}{\Delta t} = -NBA\left(\frac{\Delta(\cos\omega t)}{\Delta t}\right)$$

Such a generator is also called an alternator.
the emf as a function of time (voltage) $\mathcal{E} = \mathcal{E}_0 \sin\omega t$

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- in common usage, we refer to the frequency rather than the angular frequency

$$\mathcal{E} = \mathcal{E}_0 \sin(2\pi f t)$$

- an electric motor has a loop rotating in a magnetic field, and will also create an induced emf. this back emf is given by:

$$\mathcal{E}_b = V - IR$$

it limits the current in a motor and can help protect it.