Phys 112 2019

Lecture 21

Thurs: Seminar

Fri: HW by 5pm

Supp 76, 77, 78, 79, 80

Ch 25 Prob 19, 20, 60

After Fall break

Mon Warm Up 9

Tues / Weds Exam / review

Induction and Lenz's law

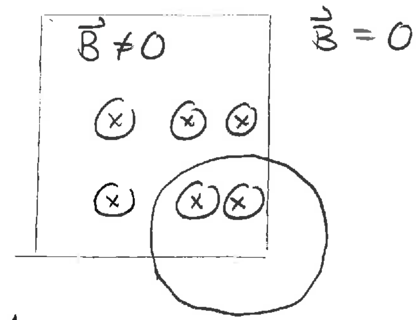
The general rule that establishes whether a magnetic field produces a current is:

> A magnet field will induce an EMF and a current in a loop whenever the magnetic flux through the loop changes with time.

Then Lenz's law gives the direction of the EMF via the direction of the induced current

> The direction of the induced current is such that it produces an induced magnetic field which opposes the change in the external magnetic field.

Example: A loop is partly situated in the illustrated loop. Determine the direction of the induced current if:

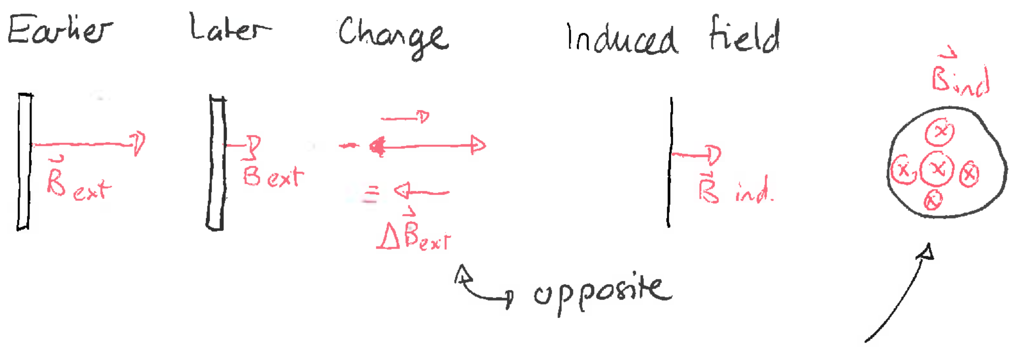


a) the field decreases with time

b) the loop is pushed further into the field, which stays constant with time.

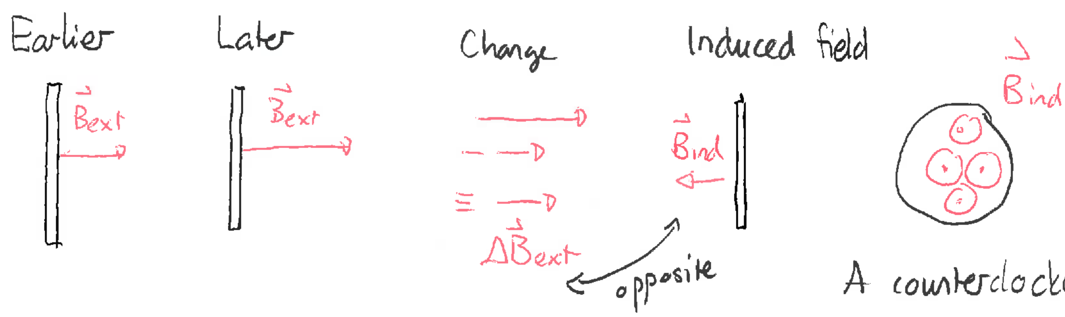
Answer Consider a side view from the right in each case

a)



A clockwise current will produce this.

b)



A counterclockwise current produces this.

Quiz 1 80%

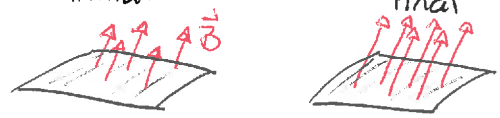
Quiz 2 about 50%

Demo Jumping ring.

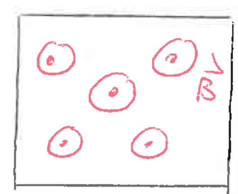
Demo: Tube and magnet.

Faraday's Law

We need a law that quantifies the EMF or current that is induced by a magnetic field. Faraday's Law provides this

> The magnitude of the EMF that is produced by a changing flux is:
>
> $$\mathcal{E} = \left|\frac{\Delta \Phi}{\Delta t}\right| = \left|\frac{\Phi_f - \Phi_i}{t_f - t_i}\right|$$
>
> initial | final
>
> 
>
>
> Flux Φ_i | Φ_f
>
> time t_i | time t_f

Example: A loop with area $2.0 \times 10^{-3}\,m^2$ is placed in a region of uniform magnetic field, which is perpendicular to the loop. The field decreases at a steady rate from $16\,T$ to $0\,T$ over $2.0\,ms$. The resistance of the loop is $2.5\,\Omega$



Determine:

a) the EMF around the loop

b) the current around the loop.

Answer: a) $\mathcal{E} = \left|\frac{\Delta\Phi}{\Delta t}\right| = \left|\frac{\Phi_f - \Phi_i}{t_f - t_i}\right|$

We need the fluxes given via

$$\Phi = BA\cos\theta$$

with $\theta = 0°$

$$\Rightarrow \Phi = BA\cos 0° = BA$$

Then $\Phi_i = B_i A$

$= 16T \times 2.0 \times 10^{-3} m^2 = 32 \times 10^{-3} Wb$

$\Phi_f = B_f A = 0 \, Wb$

$\Rightarrow \quad \mathcal{E} = \left| \frac{0 \, Wb - 32 \times 10^{-3} Wb}{2.0 \times 10^{-3} s} \right| \Rightarrow \boxed{\mathcal{E} = 16V}$

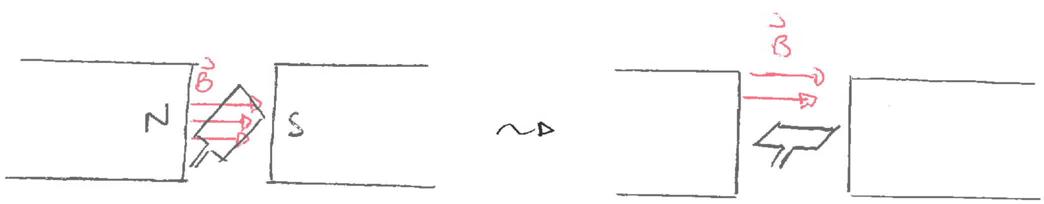
b) $\mathcal{E} = IR \Rightarrow 16V = I \, 2.5\Omega$

$\Rightarrow I = \frac{16V}{2.5\Omega} \Rightarrow \boxed{I = 6.4A}$

Quiz 3 70% →

Electric generators

We can use the fact that a time varying magnetic field induces currents to generate current. This can be done by rotating a loop in a field produced by permanent magnets.



Because the angle between field + loop changes, the flux changes with time and this induces an EMF and hence a current

Demo: PhET Generator

-run water

* Transformer?