Lecture 20

Tues: Discussion / quiz
Supp 71, ~~72~~, 73, ~~74~~, 75

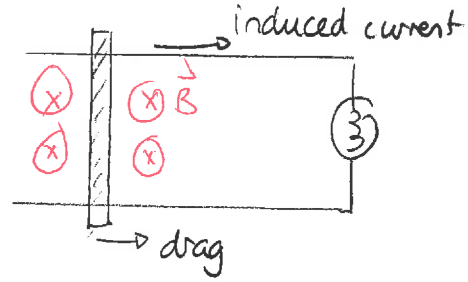
Ch 25 Q 5

Ch 25 Prob 2, 9, 10

Weds: PRELABS

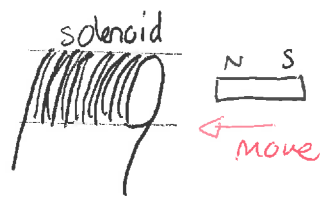
Current produced by fields

The fact that a magnetic field can exert a force on a moving charge means that we can produce currents by dragging wires in magnetic fields.



A further observation is that moving a magnet in the presence of a wire can produce a current in that wire

Demo: Move ~~so~~ magnet near solenoid



The resulting current is called an induced current (ie. induced by the changing field).

The induced current is the result of an induced EMF (or voltage around the loop). Thus:

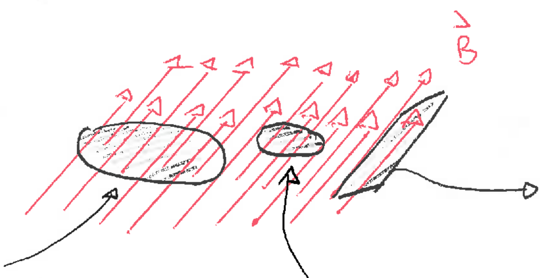
> If the magnetic field through a loop changes as time passes then there will be an induced current and an induced EMF around the loop.

The origins of this cannot be due to motional magnetic forces

Magnetic flux

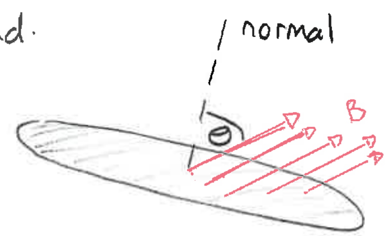
The rule that establishes what the induced EMF (and therefore the current) around the loop will be requires a notion of the total magnetic field encompassed by the loop. We will use:

> magnetic flux ≡ extent to which magnetic field vectors pierce the loop.



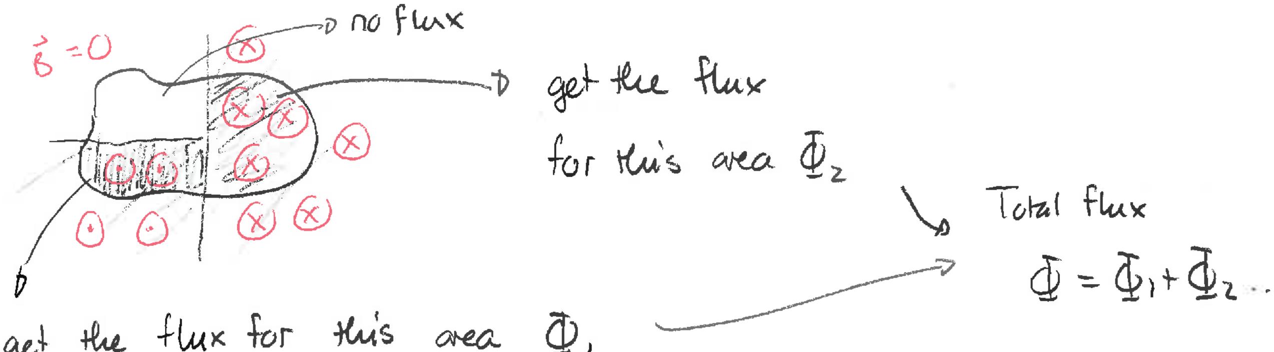
The definition of flux is

> Consider a flat loop in a uniform magnetic field. The magnetic flux through this loop is
>
> $$\Phi = AB\cos\theta$$
>
> where B = magnitude of field
> A = area of loop
> θ = angle between normal to loop and field



The units of flux are Webers $Wb = Tm^2$

If the field is not uniform then the loop must be broken into segments, the flux calculated for each and the results added.



~~Warm Up~~

Then

> If the magnetic flux through a loop changes with time, there will be an induced EMF around the loop.

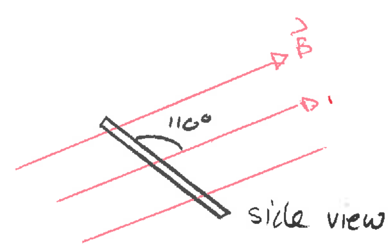
Quiz 1

Quiz2

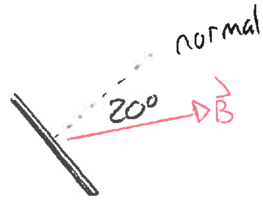
Warm Up 1

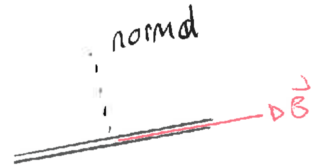
We will use changes in flux to determine the EMF around a loop.

Example: A loop with area $4.0\,m^2$ is placed within the illustrated uniform field with strength 0.050T. It rotates until it is parallel with the field. Determine the change in flux.



Answer:





In both cases

$$\Phi = AB\cos\theta$$

$$= 4.0\,m^2 \times 0.050\,T\cos\theta = 0.20\,Wb\cos\theta$$

Initially $\theta = 20°$

$$\Rightarrow \Phi_i = 0.20\cos 20° = 0.19\,Wb$$

Finally $\theta = 90°$

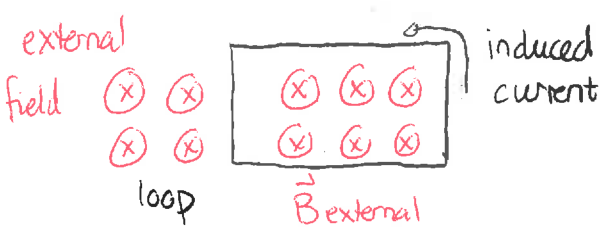
$$\Rightarrow \Phi_f = 0.20\cos 90° = 0\,Wb$$

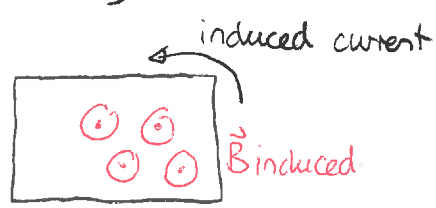
So $\Delta\Phi = \Phi_f - \Phi_i = -0.19\,Wb$

Warm Up 2

Lenz's law

The flux will be used to give the magnitude of the induced EMF and the resulting current. We need a rule for the direction of the induced current. This uses the following scheme.



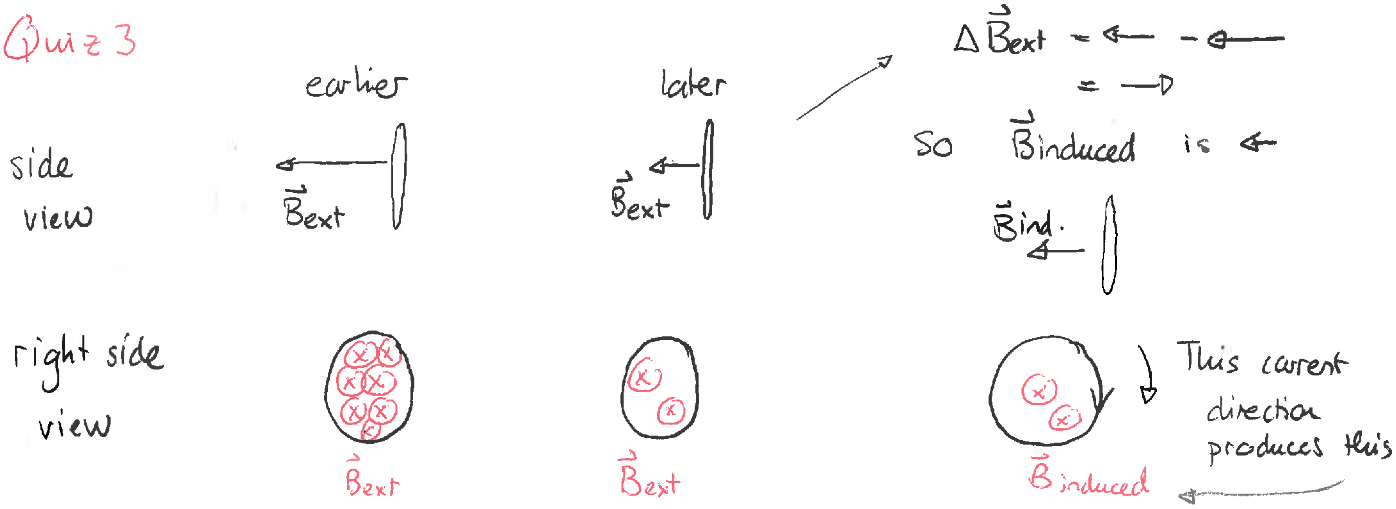


induced current produces another induced magnetic field (use r.h. to get direction)

Then Lenz's law states that

The direction of the induced field and current are such that the induced magnetic field <u>opposes</u> the <u>change</u> in the external field

Quiz 3


earlier
later
side view
$\vec{B}_{ext}$
$\vec{B}_{ext}$
$\Delta \vec{B}_{ext}$ = ← − ←
= →
So $\vec{B}_{induced}$ is ←
$\vec{B}_{ind.}$
right side view
$\vec{B}_{ext}$
$\vec{B}_{ext}$
$\vec{B}_{induced}$
This current direction produces this