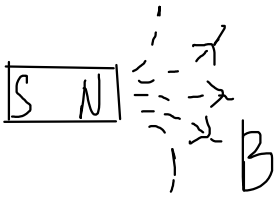
Magnetic Flux

Dr K M Hock

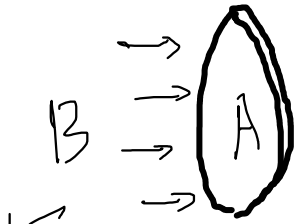


A changing field induces an e.m.f. in a loop.

Induced e.m.f. proportional to field B and area A:

$E \propto BA$

e.g.



for uniform B ⊥ A,

$\Phi = BA$ called magnetic flux

1 T $1\ m^2$ (phi)

SI Unit of magnetic flux is Weber (Wb).

e.g. $BA = 1\ T \times 1\ m^2 = 1\ Wb$.

Magnetic Flux 2

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e.g. $\perp$ Area A

B 0.5 T

$0.01\,m^2$

$\Phi = BA$

$\Phi = 0.5 \times 0.01$

$= 0.005\,Wb$

e.g. // area

B 0.5 T

A

$0.01\,m^2$

Flux

$\Phi = 0\,Wb$

(must cross A)

e.g. B 60° to N

B 0.5 T

60°

A

N

(normal)

B's component // N

is $B\cos 60^\circ$

$= 0.5 \times \frac{1}{2} = 0.25\,T$

$\Phi = 0.25\,T \times 0.01\,m^2$

e.g. B angle θ to N

A

θ

N

(normal)

$\Phi = BA\cos\theta$

e.g. if B is not uniform ??

Magnetic Flux Linkage

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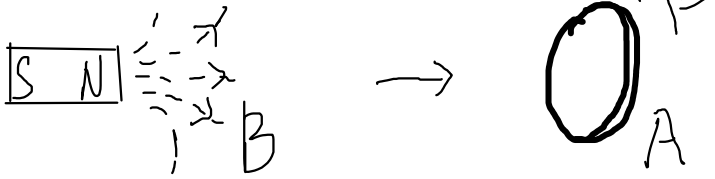


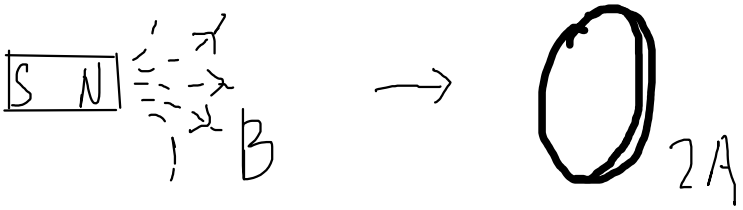
Induced e.m.f. $\propto$ flux change

What if coil has 2 turns?

Turns in series → like battery,

emf's add → $E + E = 2E$

Same effect as 1 turn with area $A \times 2$.



flux $\phi = 2BA$

Coil with N turns,

$$N\phi = NBA$$ – called flux linkage

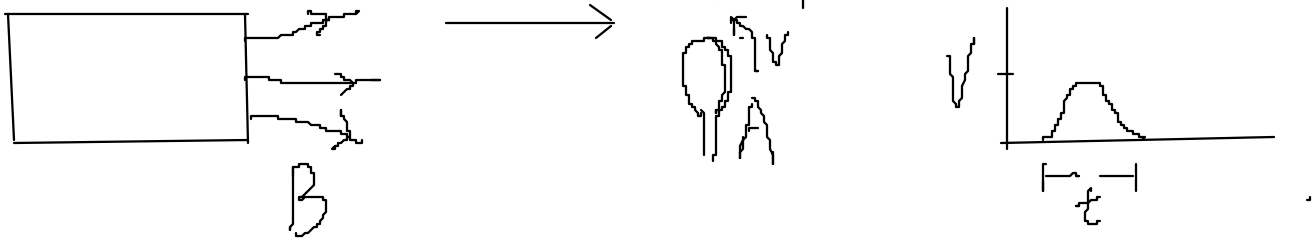
$\therefore$ Induced e.m.f. $\propto$ flux linkage

infer from appropriate experiments on electromagnetic induction:
that a changing magnetic flux can induce an e.m.f. in a circuit

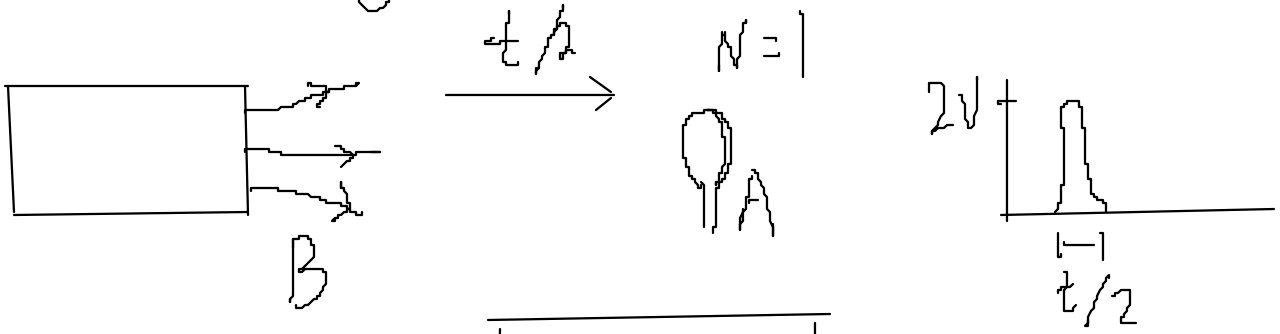
Electromagnetic Induction

Dr K M Hock

Change of field thru' coil induces voltage.

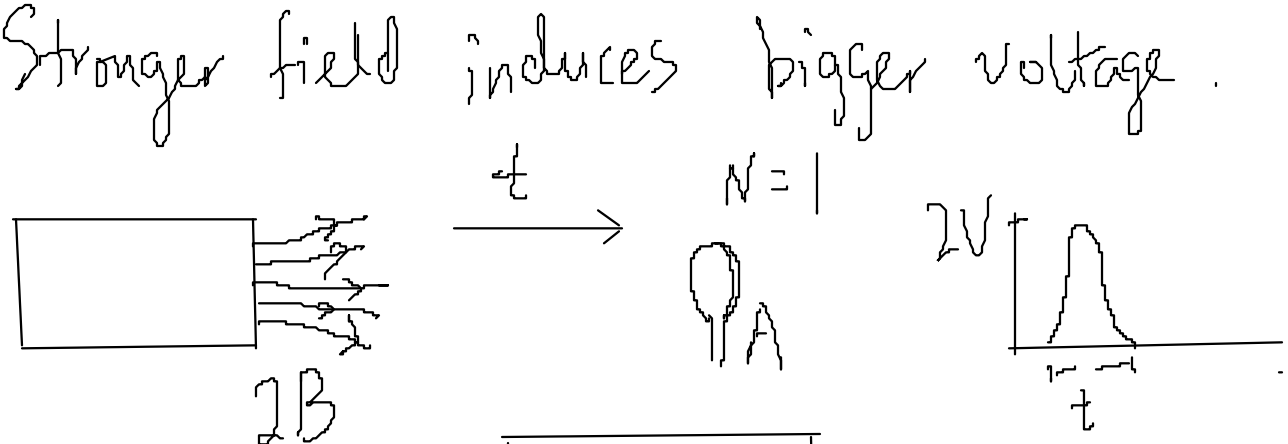


Faster change induces bigger voltage.



$$V \propto \frac{1}{t}$$

Stronger field induces bigger voltage.



$$V \propto B$$

infer from appropriate experiments on electromagnetic induction:
the factors affecting the magnitude of the induced e.m.f.

Electromagnetic Induction 2

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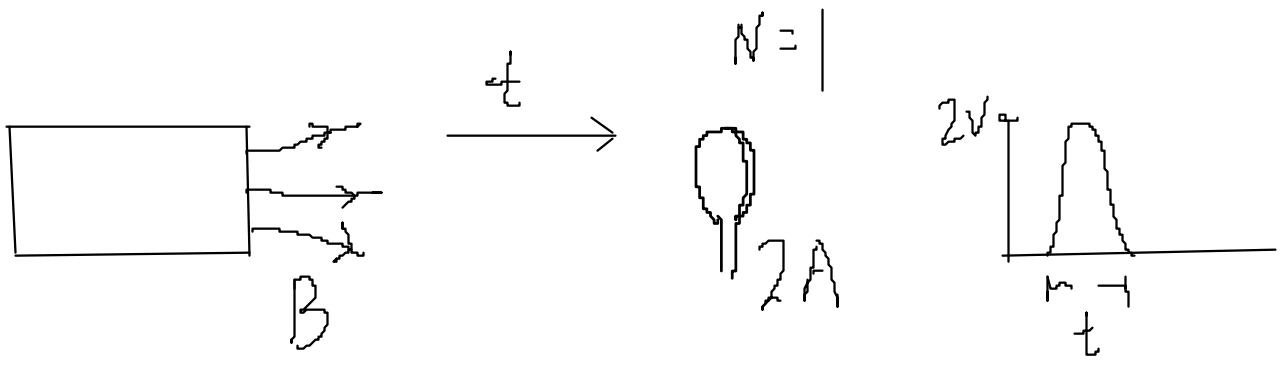
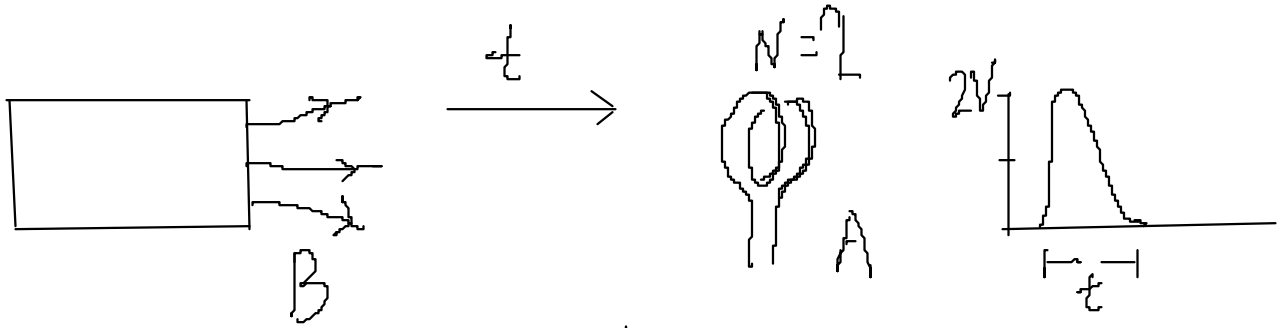
Larger coil area gives bigger voltage



$V \propto A$

More turns give bigger voltage.



$V \propto N$

Combining: $V \propto \frac{NBA}{t}$ ← flux linkage

Faraday's law: $V = -\frac{N d\Phi}{dt}$

Voltage induced in coil = rate of change of flux linking the coil

infer from appropriate experiments on electromagnetic induction:
that the direction of the induced e.m.f. opposes the change producing it

Direction of Induced e.m.f.

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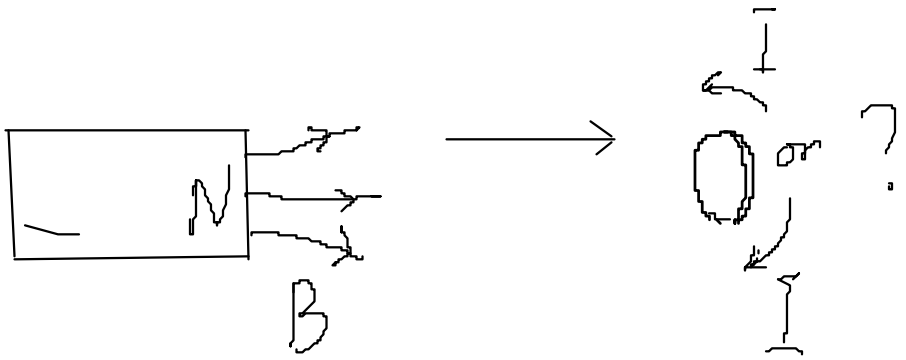
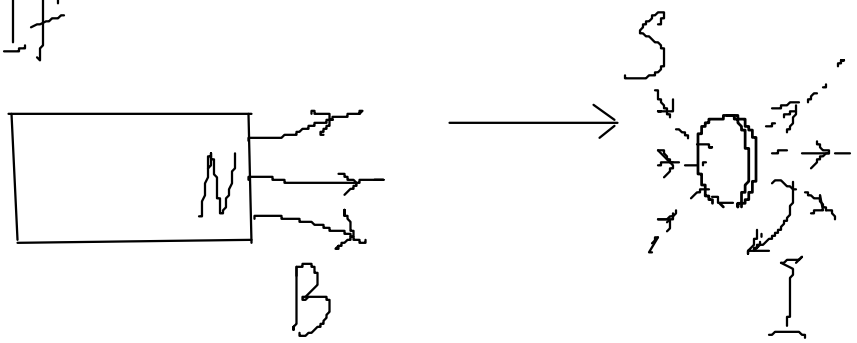


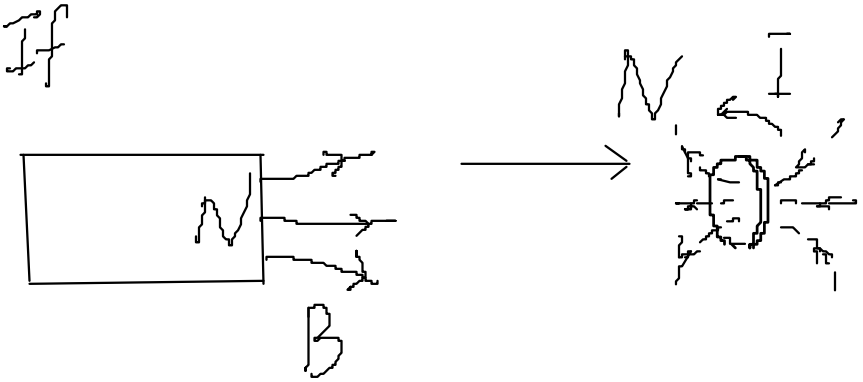
If



Unlike poles attract → energy created

~~Conservation of Energy~~

If



Like poles repel → must push magnet to get Current. ✓

Lenz's Law

E.m.F. induced is in such a direction as to oppose the change producing it.

explain simple applications of electromagnetic induction.

Applications

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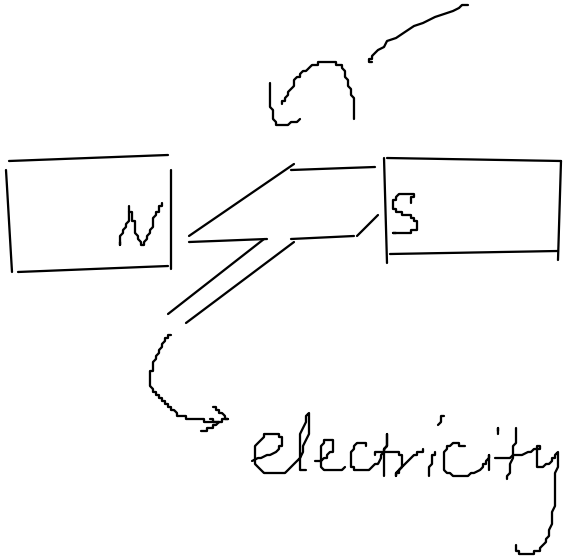
Generator

waterfall, steam, ...



Converts mechanical work to electricity

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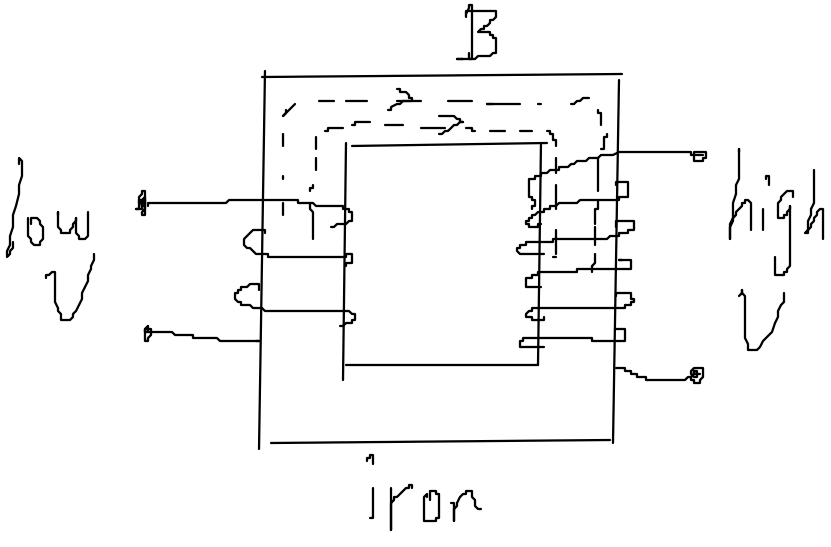
home, factories, ...

Transformer



Steps up low voltage to high voltage

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power transmission