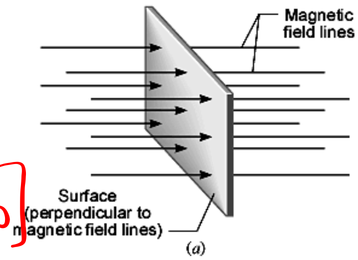
Magnetic Flux: number of field lines

Symbol: ϕ **Units:**

Formula: $\phi = B \cdot A$ $[T \cdot m^2] = [Wb]$

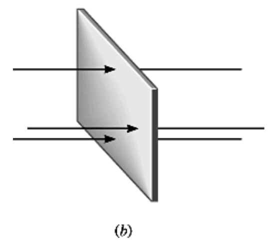


Magnetic Flux Density (field strength/intensity):

number of field lines per unit area

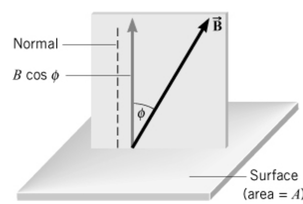
Symbol: $\vec{B}$ **Units:** $[T] = \left[\frac{Wb}{m^2}\right]$

Formula: $\vec{B} = \phi / A$



1. What is the amount of magnetic flux if the field lines are not perpendicular to the cross-sectional area?

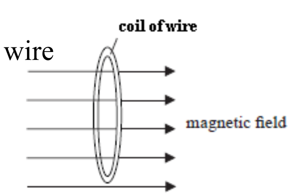
Only the perpendicular component of the magnetic field contributes to the magnetic flux.



Formula: $\phi = B_{\perp} A = BA\cos\theta$

Where θ = angle between normal line and field lines

Magnetic flux linkage (magnetic flux linking a coil): product of magnetic flux through a coil of wire and the number of turns of the wire



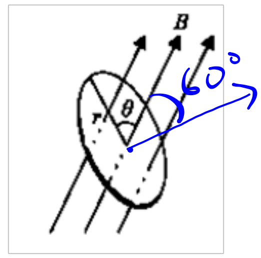
Formula: $N\phi = NBA\cos\theta$

Units: $[Wb]$

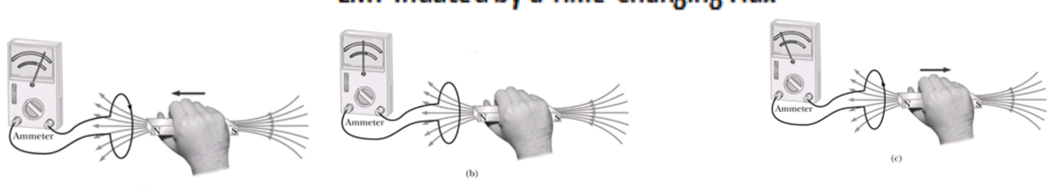
2. A coil whose diameter is 2.0 cm consists of fifty turns of wire and sits in a magnetic field whose strength is 0.30 T. The plane of the coil makes an angle of 30° to the magnetic field, as shown. Calculate the flux linkage through the coil.

$NBA\cos\theta$

$50 \cdot .3T(\pi \cdot .01m^2)\cos 60$ or $\sin 30°$



EMF Induced by a Time-Changing Flux



Moving a magnet towards a coil will Increase the magnetic flux linking the coil and will induce an emf and a current in a certain direction

Holding the magnet stationary will not change the amount of magnetic flux linking the coil and so will not induce an emf or current.

Moving the magnet away from the coil will decrease the magnetic flux linking the coil and will induce an emf and a current in the opposite direction.

Faraday's Law:

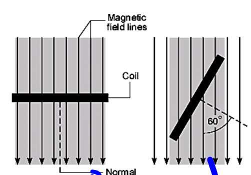
an induced emf is proportional to the rate of change of the flux linkage

Formula:

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

$$= -N\frac{\Delta BA\cos\theta}{\Delta t}$$

1. A coil of area 0.030 m^2 with 300 turns of wire rotates as shown in 0.10 second in a magnetic field whose intensity is 0.25 T.



a) What is the induced emf?

$$\mathcal{E} = -NBA\frac{\Delta\cos\theta}{\Delta t} = -300\cdot 0.25T\cdot 0.03m^2\,\frac{(\cos 60^\circ - \cos 0)}{.1s}$$

$$= 11.3V$$

b) What is induced emf if the coil were stationary at 0^0 but the field strength changed from 0.25 T to 0.60 T in 0.10 second?

$-31.5V$

2. A 50 turn coil of wire of area 0.20 m^2 is perpendicular to a magnetic field that varies with time as shown.

a) Determine the emf induced in the coil during each time interval.

$\varepsilon = -NA\cos\theta \cdot \frac{\Delta B}{\Delta t}$

$= -50 \cdot .2m^2 \left(\frac{-.6T}{2s}\right)$

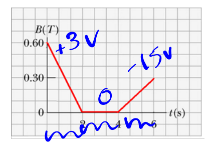
$\left(\frac{0}{2s}\right)$

$\left(\frac{+.3T}{2s}\right)$

$\Delta B = -.6T$

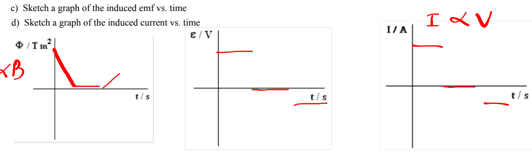
$\Delta B = 0$

$\Delta B = +.3T$



b) Sketch a graph of the flux vs. time
c) Sketch a graph of the induced emf vs. time
d) Sketch a graph of the induced current vs. time

$\phi \propto B$ $\quad$ $I \propto V$

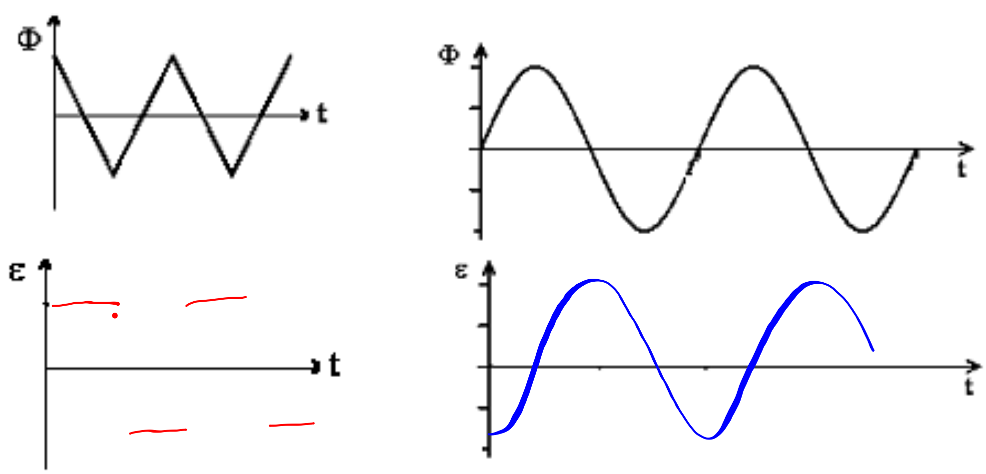


b) Sketch a graph of the flux vs. time.

c) Sketch a graph of the induced emf vs. time

d) Sketch a graph of the induced current vs. time.

3. For each time-varying flux graphed below, sketch a graph of the induced emf.



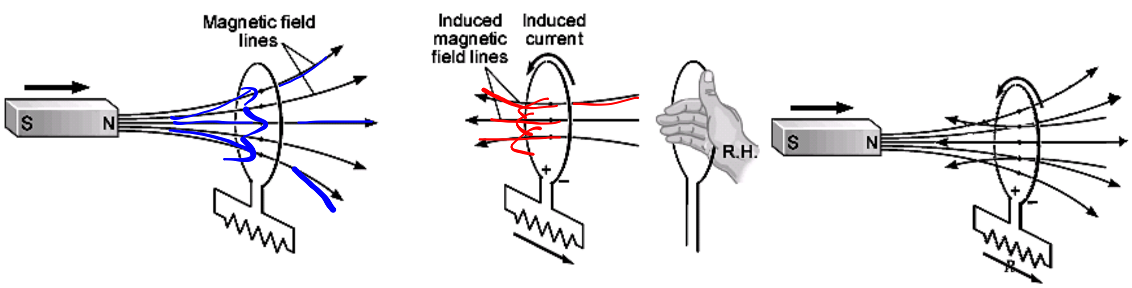
Note: emf is out of phase with flux by 1/4 period

Lenz's Law

Lenz's Law - The direction of an induced emf is such that it produces a magnetic field whose flux opposes the flux change that induced it.

Meaning: An induced emf will keep the net flux constant.

Original Flux Change | Induced EMF and Flux | Resultant Flux

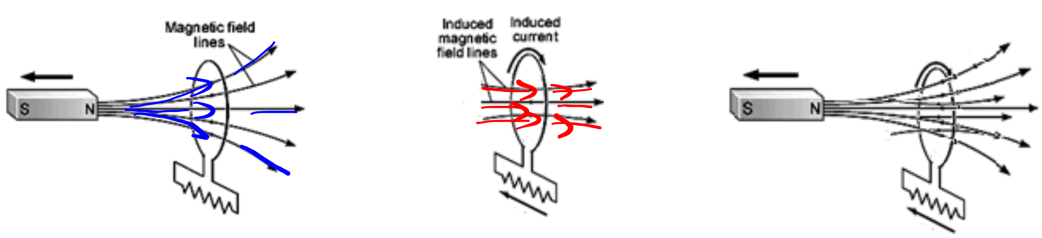


Increasing Flux

Nature opposes increasing flux by having induced flux point in opposite direction

Result: Net flux linking the loop is held constant

Original Flux Change | Induced EMF and Flux | Resultant Flux



Decreasing Flux

Nature opposes decreasing flux by having induced flux point in same direction

Result: Net flux linking the loop is held constant