Chapter 20

$\vec{F} = q\vec{v}\times\vec{B}, \left|\vec{F}\right| = qvB\sin\phi$ Force on a charge with velocity v traveling through a region of space with magnetic field B, direction give by R.H.R

$F = |q|vB = m\dfrac{v^2}{R}$ Motion of charged particle in magnetic field with uniform circular motion. The B field is perpendicular to the velocity.

$\vec{F} = I\vec{L}\times\vec{B},$ $F = ILB\sin\phi$ Force on a conductor with current I & length L in a region of space with magnetic field B. The direction of force given by R.H.R

$\vec{\tau} = \sum \vec{r}\times\vec{F}$, $\vec{\tau} = \vec{\mu}\times\vec{B}$, $\vec{\mu} = INA\hat{n}$ The torque on a loop. The sum is over all segments of the loop. Alternatively you can use μ x B. Where μ is the direction normal to the surface and its magnitude is I the current time the area A. Multiply by the number of turns N if more than one loop.

$B = \dfrac{\mu_0 I}{2\pi r}$, $\mu_0 = 4\pi\times10^{-7}\,\mathrm{T\cdot m/A}$ The magnitude of the field B, a distance r away from a long straight conductor with current I

$B = \dfrac{\mu_0 I}{2R}$ The magnitude of the B field at the center of a single loop of radius R with current I. The direction is given by R.H.R. If there are N loops multiply by N

$B = \mu_0 n I$ The magnitude of the B field inside a long coil with $n = N/l$ and current I. N is the total number of turns and l the length. The direction points along the length of the coil RHR

$B = \dfrac{\mu_0 N I}{2\pi r}$ The magnitude of the B field inside a toroid with N turns, current I and at distance r from the center of toroid. The direction of the field is tangent to a circle at radius r and consistent with the R.H.R.

$\dfrac{\vec{F}}{L} = \dfrac{\mu_0 I I'}{2\pi r}$ The force per unit length btw two parallel conductors with current I and I' and separated by distance r. The direction is given by the right (ILxB)

Chapter 23

$E = cB,\ c = \lambda f$ The electric field and magnetic fields are related by the speed of light in eletromagnetic E&M waves.

$c = \dfrac{1}{\sqrt{\mu_0\varepsilon_0}}$ The speed of light is a function only of constants μ_0 and ε_0, $c = 3 \times 10^8$ m/s

$E = E_{\max}\sin(\omega t + kx)$, $B = B_{\max}\sin(\omega t + kx)$ A sinusoidal transverse wave propagating through space with E & B field perpendicular to direction of motion.

$u = \dfrac{1}{2}\varepsilon_0 E^2 + \dfrac{1}{2\mu_0}B^2 = \varepsilon_0 E^2$ u is the energy density energy per unit volume in an E&M wave

$S = \dfrac{Power}{Area} = \dfrac{\Delta U/\Delta t}{A}$ S is power or energy flow per unit area, either radiated by a source or absorbed by an object

$I = S_{ave} = \dfrac{1}{2}\varepsilon_0 c E_{\max}^2 = \dfrac{E_{\max}B_{\max}}{2\mu_0}$ S_{ave} is the average energy flow per or power per unit area, a.k.a. Intensity I

$\dfrac{p_{ave}}{V} = \dfrac{S_{ave}}{c^2}$ The average momentum of an E&M wave per unit volume

$P = \dfrac{S_{ave}}{c}$ The pressure P exerted by an E&M wave

$T = \dfrac{2\pi}{\omega}, \omega = 2\pi f : k = \dfrac{2\pi}{\lambda}$ T is the period, f is the frequency and k is the wave number

$n = \dfrac{c}{v},\ \ \lambda = \dfrac{\lambda_0}{n}$ The index of refraction, the speed of light and wavelength in vacuum, c and λ_0

$\theta_{incident} = \theta_{reflected}$, $n_a\sin\theta_a = n_b\sin\theta_b$ Law of reflection and Snell's Law, a and b correspond to different media

$\sin\theta_{critical} = \dfrac{n_b}{n_a}$ The critical angle corresponds the angle at which total internal reflection occurs

$I = I\cos^2\phi$ The intensity through polarizer for incident light that is polarized at angle ϕ

$I = I_0/2$ The intensity through polarizer for incident unpolarized light

Chapter 21

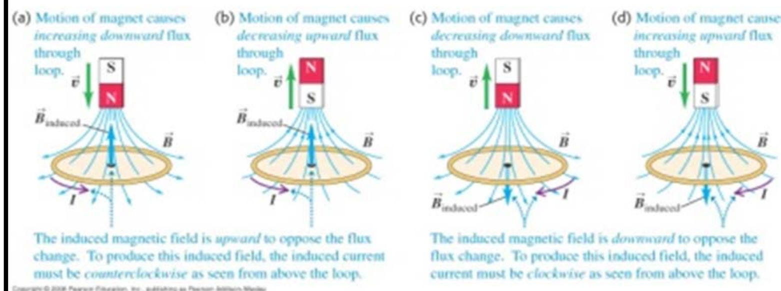
The magnetic flux

$\Phi_B = \vec{B}\cdot\vec{A} = \left|\vec{B}\right|\left|\vec{A}\right|\cos\phi$ is the product of the B field, area A and the cosine of the angle btw the normal to the surface area and B field ϕ.

Faraday's Law: $\mathcal{E} = \left|\dfrac{\Delta\Phi_B}{\Delta t}\right|$

The time rate of change in the flux is equal to the electromotive force. The change in flux can be caused by a change in B field, a change in the Area or the angle btw the direction of B field, normal to surface the angle ϕ. If there are more than one loop multiply above by number of loops N

Lenz's Law: The direction of magnetically induced current or emf is such as to oppose the direction for the phenomena causing it.

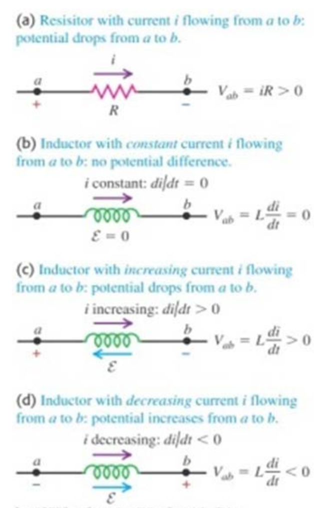


$\mathcal{E} = V_{ab} = EL = vBL$ Motional emf produced by a moving rod (v) on a stationary conductor, slide generator

$M_{12} = M_{21} = \left|\dfrac{N_2\Phi_{B2}}{i_1}\right| = \left|\dfrac{N_1\Phi_{B1}}{i_2}\right|$ Mutual inductance btw coils 1 and 2.

The emf on coil 1(2) is caused by the rate of change in current on coil 2(1). $\mathcal{E}_2 = M\left|\dfrac{\Delta i_1}{\Delta t}\right|,\ \ \mathcal{E}_1 = M\left|\dfrac{\Delta i_2}{\Delta t}\right|$

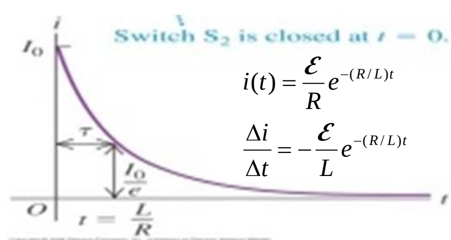
$L = \left|\dfrac{N\Phi_B}{i}\right|,\ \mathcal{E} = L\left|\dfrac{\Delta i}{\Delta t}\right|$ Self inductance & emf from inductor



Energy U and energy density u in an inductor. $U = \dfrac{1}{2}LI^2,\ u = \dfrac{B^2}{2\mu_0}$

Transformers

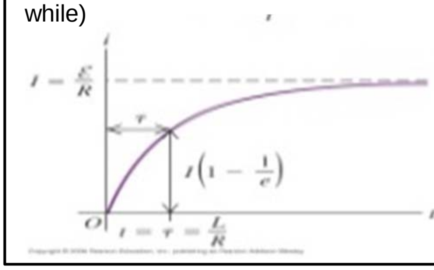
$\dfrac{\mathcal{E}_2}{\mathcal{E}_1} = \dfrac{N_2}{N_1},\ \ \dfrac{I_1}{I_2} = \dfrac{N_2}{N_1}$ 2 & 1 here correspond to different transformer's two coils. In transformers $P_1 = P_2$ also Ohm's Law V=IR applies and P=IV.



$i(t) = \dfrac{\mathcal{E}}{R}e^{-(R/L)t}$

$\dfrac{\Delta i}{\Delta t} = -\dfrac{\mathcal{E}}{L}e^{-(R/L)t}$

For an R-L circuit, the time-dependent current for decaying current, fig. above (switch is closed for a while & then opened) and for an increasing current, fig. below (switch closed after being opened for a while)



$i(t) = \dfrac{\mathcal{E}}{R}\left(1 - e^{-(R/L)t}\right)$

$\dfrac{\Delta i}{\Delta t} = \dfrac{\mathcal{E}}{L}e^{-(R/L)t}$