Magnetism: Important Equations

elementary charge	$e = 1.60 \times 10^{-19}$ Coulomb
force on a moving charge	$\vec{\mathbf{F}} = q\,\vec{\mathbf{v}} \times \vec{\mathbf{B}}$ (B field only)
force on a moving charge	$\vec{\mathbf{F}} = q\vec{\mathbf{E}} + q\,\vec{\mathbf{v}} \times \vec{\mathbf{B}}$ (E and B fields)
force on a piece of straight wire	$\vec{\mathbf{F}} = i\vec{\mathbf{L}} \times \vec{\mathbf{B}}$
torque on a current loop	$\vec{\tau} = NiA\,\hat{\mathbf{n}} \times \vec{\mathbf{B}}$
magnetic constant	$\mu_o = 1.26 \times 10^{-6}$ Henry/meter
force between two straight wires	$F = \dfrac{\mu_o L i_1 i_2}{2\pi d}$
cyclotron radius	$r = \dfrac{mv}{\lvert q\rvert B}$
cyclotron frequency	$\omega = \dfrac{\lvert q\rvert B}{m}$ (or) $f = \dfrac{\lvert q\rvert B}{2\pi m}$
Biot-Savart Law	$\vec{\mathbf{B}} = \dfrac{\mu_o}{4\pi}\dfrac{q\vec{\mathbf{v}} \times \vec{\mathbf{r}}}{r^3}; \lvert B\rvert = \dfrac{\mu_o}{4\pi}\dfrac{\lvert q\rvert v \sin\phi}{r^2}$
magnetic field of a current	$\vec{\mathbf{B}} = \dfrac{\mu_o}{4\pi}\int \dfrac{i\vec{\mathbf{ds}} \times \vec{\mathbf{r}}}{r^3}$
magnetic field of straight wire	$\lvert B\rvert = \dfrac{\mu_o i}{2\pi d}$
mag field of a circular current loop	$\lvert B\rvert = \dfrac{\mu_o i}{2R}$ (measured at the center; times number of turns N)
mag field inside a long solenoid	$\lvert B\rvert = \mu_o n i$
Ampère's Law	$\oint \vec{\mathbf{B}} \cdot \vec{\mathbf{ds}} = \mu_o I + \mu_o \epsilon_o \dfrac{d}{dt}\iint \vec{\mathbf{E}} \cdot \vec{\mathbf{dA}}$
definition of magnetic flux	$\Phi_B = \iint \vec{\mathbf{B}} \cdot \vec{\mathbf{dA}}$
Faraday's Law of Induction	$\mathcal{E} = -\dfrac{d\Phi_B}{dt}$ (times number of turns N)
definition of the EMF around a loop	$\mathcal{E} = \oint \vec{\mathbf{E}} \cdot \vec{\mathbf{ds}}$ (times number of turns N)
Faraday's Law of Induction	$\oint \vec{\mathbf{E}} \cdot \vec{\mathbf{ds}} = -\dfrac{d}{dt}\iint \vec{\mathbf{B}} \cdot \vec{\mathbf{dA}}$ (equivalent form)

Inductance, AC, Maxwell's Equations, Waves: Important Equations

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Definition of inductance L	$\mathcal{E}_L = L\dfrac{di}{dt}$
Calculation of L from flux	$L = \dfrac{N\Phi_B}{i}$

Inductance of a solenoid	$\frac{L}{l} = \mu_o n^2 A$
Time constant of an LR circuit	$\tau_L = \frac{L}{R}$
Energy stored in an inductor L	$U_B = \frac{1}{2} L i^2$
Energy stored in a capacitor C	$U_E = \frac{q^2}{2C}$
Energy density of E and B field	$u = \frac{\epsilon_o E^2}{2} + \frac{B^2}{2\mu_o}$
Resonant frequency of LC oscillator	$\omega = 2\pi f = \frac{1}{\sqrt{LC}}$
Ohm's Law for a resistor R	$\Delta V_R = iR \quad (i \text{ and } V \text{ in phase})$
Reactance of an inductor L	$(\Delta V_L)_{\text{max}} = i_{\text{m}} X_L,\ X_L = \omega L \quad (i\ 90^\circ \text{ behind } V)$
Reactance of a capacitor C	$(\Delta V_C)_{\text{max}} = i_{\text{m}} X_C,\ X_L = \frac{1}{\omega C} \quad (i\ 90^\circ \text{ ahead of } V)$
Impedance of an RLC circuit	$Z = \sqrt{R^2 + (X_L - X_C)^2},\ V_{\text{m}} = i_{\text{m}} Z$
Voltages of a transformer	$\frac{\Delta V_p}{N_p} = \frac{\Delta V_s}{N_s}$
Maxwell's equations	$\oiint \vec{\mathbf{E}} \cdot \mathbf{d}\vec{\mathbf{A}} = q/\epsilon_o \quad \text{(Gauss's law for electricity)}$
	$\oiint \vec{\mathbf{B}} \cdot \mathbf{d}\vec{\mathbf{A}} = 0 \quad \text{(Gauss's law for magnetism)}$
	$\oint \vec{\mathbf{E}} \cdot \mathbf{d}\vec{\mathbf{s}} = -\frac{d}{dt} \iint \vec{\mathbf{B}} \cdot \mathbf{d}\vec{\mathbf{A}} \quad \text{(Faradays's Law)}$
	$\oint \vec{\mathbf{B}} \cdot \mathbf{d}\vec{\mathbf{s}} = \mu_o I + \mu_o \epsilon_o \frac{d}{dt} \iint \vec{\mathbf{E}} \cdot \mathbf{d}\vec{\mathbf{A}} \quad \text{(Ampère's Law)}$
Wave frequency and wavelength	$\omega = 2\pi f = \frac{2\pi}{P}; \quad k = \frac{2\pi}{\lambda}; \quad \frac{\omega}{k} = \lambda f = \text{wave speed}$
Wave: Example propagating along $\hat{\mathbf{i}}$	$\vec{\mathbf{E}}(x,t) = E_{\text{m}} \sin(kx - \omega t)\, \hat{\mathbf{j}}$
	$\vec{\mathbf{B}}(x,t) = B_{\text{m}} \sin(kx - \omega t)\, \hat{\mathbf{k}}$
Wave field strengths and wave number	$\frac{E_{\text{m}}}{B_{\text{m}}} = \frac{\omega}{k} = c = \frac{1}{\sqrt{\epsilon_o \mu_o}} = 3.00 \times 10^8 \text{ m/s}$
Wave energy flow: Poynting vector	$\vec{\mathbf{S}} = \frac{1}{\mu_o} \vec{\mathbf{E}} \times \vec{\mathbf{B}}$
Wave: Perpendicular vector directions	$\vec{\mathbf{E}}$, $\vec{\mathbf{B}}$, $\vec{\mathbf{S}}$ form a right-handed triad
Wave Intensity: (power per unit area)	$I = \frac{E_{\text{m}}^2}{2\mu_o c} = \frac{E_{\text{rms}}}{\mu_o c}$
Wave: Radiation pressure	$\frac{F_{\text{av}}}{A} = \frac{I}{c} \text{ (absorption)}; \quad \frac{F_{\text{av}}}{A} = \frac{2I}{c} \text{ (reflection)}$