Magnetic Fields

Equations:

Force on a charged particle:

$$F = qvB \sin\theta$$

θ = angle between $\vec{v}$ and $\vec{B}$.
Force on a segment of wire:

$$F = I\ell B \sin\theta$$

θ = angle between $\vec{I}$ and $\vec{B}$, ℓ is the length of segment.
Torque on a current loop-coil:

$$\tau = INAB \sin\theta$$

A is area of loop, N is number of loops in coil, θ = angle between line $\perp$ to plane of loop and $\vec{B}$.
Ampere's Law:

$$B\ell = \mu_0 I$$

ℓ is length of path which encloses current I and is always parallel to $\vec{B}$. Otherwise $\cos\theta$ enters.
Magnetic field of long straight wire:

$$B = \frac{\mu_0 I}{2\pi r}$$

Magnetic field inside solenoid:

$$B = \mu_0 I \frac{N}{\ell}$$

N is the number of turns, ℓ is the length.
Faraday's Law of Electromagnetic Induction:

$$\mathcal{E} = -N\frac{\Delta\Phi}{\Delta t} \qquad \Phi = BA$$

$\mathcal{E}$ is the Voltage (induced EMF), A is the area of a single loop and N is the number of loops.
Definition of self-inductance L:

$$N\Phi = LI \qquad \mathcal{E} = -L\frac{\Delta I}{\Delta t}$$

Inductance of solenoid:

$$L = \mu_0 n^2 A\ell$$

n is the number of turns per length.
Transformer:

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

V_p V_s are the voltages across primary/secondary coils. N_p N_s are the number of turns.
Constants:

$$\mu_0 = 4\pi \cdot 10^{-7}\left(\frac{T\ m}{A}\right) \qquad \epsilon_0 = 8.85 \cdot 10^{-12}\left(\frac{C}{V\ m}\right) \qquad k = \frac{1}{4\pi\epsilon_0} = 8.99 \cdot 10^{9}\left(\frac{V\ m}{C}\right)$$

Assorted Facts:

1. Force on a moving charge in magnetic field is $\perp$ to both $\vec{v}$ and $\vec{B}$.
2. Magnetic field of long straight wire wraps around wire.
3. Parallel wires carrying current in the same direction attract each other.
4. Induced currents produce magnetic fields opposing change in magnetic flux. (Lenz' Law).

Units:

Quantity	Units	Conversion
Magnetic Field	T	$1\ T = 1\ N/(m \cdot A)$
Inductance	H	$1\ H = 1V \cdot s/A$
Impedance	Ω	$1\ \Omega = 1V/A$