Summary of Chapter 19 – Magnetism

Please read Chapter 19 carefully, and make sure that you understand the summary points below.

► The **magnetic force** that acts on a charge \( q \) moving with velocity \( \mathbf{v} \), in a magnetic field \( \mathbf{B} \) has the magnitude

\[
F = q \mathbf{v} \mathbf{B} \sin \theta
\]

where \( \theta \) is the angle between \( \mathbf{v} \) and \( \mathbf{B} \).

To find the direction of this force, use the right-hand rule: If the fingers of your right hand curl from \( \mathbf{v} \) to \( \mathbf{B} \), the thumb points in the direction of the magnetic force on a positive charge; the force on a negative charge is in the opposite direction.

► The SI unit of magnetic field is the tesla (T).

► If a straight wire of length \( L \) carries current \( I \), the magnetic force on the wire when it is placed in a uniform external magnetic field, \( \mathbf{B} \), is

\[
F = I \mathbf{L} \mathbf{B} \sin \theta
\]

The right-hand rule also gives the direction of the magnetic force on the wire. If the fingers of your right hand curl from \( \mathbf{I} \) to \( \mathbf{B} \), the thumb points in the direction of the magnetic force on the length of the wire.

► The torque, \( \tau \), on a current-carrying loop of wire in a magnetic field, \( \mathbf{B} \), has the magnitude

\[
\tau = I \mathbf{A} \mathbf{B} \sin \theta
\]

where \( I \) is the current in the loop, \( A \) is the cross-sectional area of the loop, and \( \theta \) is the angle between \( \mathbf{B} \) and the normal vector of \( A \).

► If a charged particle moves in a uniform magnetic field and its initial velocity is perpendicular to the field, then the particle will move in a circular path whose plane is perpendicular to the magnetic field. The equation of motion of the particle is

\[
\frac{mv^2}{r} = q \mathbf{v} \mathbf{B}
\]

where \( v \) is the speed. For example, the radius of the circular path is

\[
r = \frac{mv}{qB}
\]

► The magnetic field at distance \( r \) from a **long, straight wire** carrying current \( I \) has the magnitude

\[
B = \frac{\mu_0 I}{2\pi r}
\]

where \( \mu_0 = 4\pi \times 10^{-7} \text{Tm/A} \) is the permeability of free space. The magnetic field lines around a long, straight wire are circles concentric with the wire.

► **Ampere's law** can be used to find the magnetic field around certain simple current-carrying conductors. It can be written

\[
\sum B_{\text{tan}} \Delta L = \mu_0 I
\]

where \( B_{\text{tan}} \) is the component of \( \mathbf{B} \) tangent to a small current element of length \( \Delta L \) that is part of a closed path, and \( I \) is the total current that passes through the closed path.

► The force per unit length on each of two parallel wires separated by the distance \( d \) is

\[
F = \frac{\mu_0 I \Delta l}{2\pi d}
\]

The forces are attractive if the currents are in the same direction and repulsive if they are in opposite directions.

► The magnetic field inside a solenoid has the magnitude

\[
B = \mu_0 n I
\]

where \( n \) is the number of turns of wire per unit length, \( n = N/L \).