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 **v**, in a magnetic field **B** has the magnitude

$$F = qvB\sin\theta$$

where θ is the angle between **v** and **B**.

To find the direction of this force, use the right-hand rule: If the fingers of your right hand curl from **v** to **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, **B**, is

$$F = ILB\sin\theta$$

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

►The torque, τ, on a current-carrying loop of wire in a magnetic field, **B**, has the magnitude

$$\tau = IAB\sin\theta$$

where I is the current in the loop, A is the cross-sectional area of the loop, and θ is the angle between 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

$$\frac{mv^2}{r} = qvB$$

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 $\mu_0 = 4\pi \times 10^{-7}$ 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

$$\sum B_{\tan}\,\Delta L = \mu_0 I$$

where $B_{\tan}$ is the component of B tangent to a small current element of length ΔL 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

$$\frac{F}{L} = \frac{\mu_0 I_1 I_2}{2\pi d}$$

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.