Guide to: Magnetic force; Force on a current in a magnetic field; Force between currents.

Applications: Gyration of charged particles in a magnetic field, Mass spectrometer (electric and magnetic fields)

Basic idea: Magnetic fields cause deflections (acceleration) of moving charges.
An electric current represents charges moving with a drift velocity.
Charged-particle deflection given by right-hand rule.

Derivations: 1) Charged particle entering a constant-magnetic-field region (at a right angle to the velocity vector):

derive the gyration radius from $m\frac{v^2}{r} = qvB$.

2) Consider a current segment in a constant uniform magnetic field: figure out the force.
First understand how current is related to drift velocity ΔQ
Here n is the charge-carrier volume density, the volume = cross sectional area A times length Δx.
Magnetic force $\vec{F}_B = \Delta Q\ \vec{v}_d \times \vec{B}$ is re-expressed (previous two equations) as $\vec{F}_B = \Delta x \vec{I} \times \vec{B}$
where Δx is the length of (straight) wire in the field. Current direction=drift velocity direction.
See Fig. 19.6 to understand the volume $A\ \Delta x$ containing the charge that passes the cross sectional area A in time Δt.

3) Current-current force: one current is a source of magnetic field, the other experiences the magnetic force and vice versa.

Equations: gyration radius: $r = \frac{mv}{qB}$ magnetic force: $\vec{F}_B = q\ \vec{v} \times \vec{B}$ direction by right-hand rule, force magnitude: $F_B = qvB\sin\theta \quad 0 \leq \theta \leq \pi$. For current: $F_B = \Delta x\ IB\sin\theta$ for wire length $\Delta x = L$
Two parallel (or anti-parallel) currents $I_1,\ I_2$ separated by distance d: attraction (repulsion)
$F_{2\text{wires}} = \frac{\mu_0 I_1 I_2 \Delta x}{2\pi d}$ since wire1 generates $B_1 = \frac{\mu_0 I_1}{2\pi d}$ at the location of wire2 and $\sin\theta = 1$.

Problems: 20.10-44; 20.45-56; 20.62-67; 20.96-97

Use the ‘mathematics’ right-hand rule valid for any vector cross product to figure out the direction of the magnetic force. The magnetic force acts at right angle to the magnetic field direction, and at right angle to the velocity vector. Because of the latter property it does no work on the charged particle, it bends around the velocity vector, but does not affect the speed.