Summary II - Magnetism

1. Charges moving in a magnetic field experience a Lorentz force. $\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$

   B has units called Tesla. $1T = \frac{1N}{\text{Coulomb}\, m/s} = \frac{1N}{\text{Amp}\cdot m}$

2) sometimes we write the motion as a <u>current</u> instead of a velocity. In that case, the force in the current is

$$\vec{F} = I\vec{L} \times \vec{B},$$ or for current segments

$$d\vec{F} = I(d\vec{s} \times \vec{B})$$

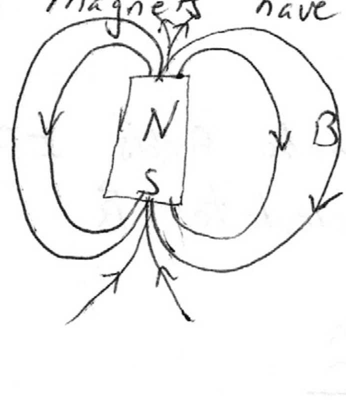
such that $\vec{F} = \int I\, d\vec{s} \times \vec{B}$

3) A charged particle moving perpendicular to a uniform magnetic field moves in a circle of radius

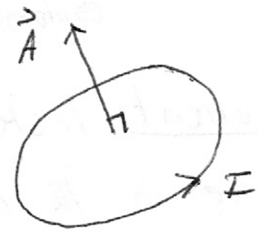
$$R = \frac{mv}{qB}$$ (can you derive this?)

4) Magnetic field lines form closed loops since there are no magnetic monopoles (no magnetic "charges")

5) magnets have north and south poles. The earth has a magnetic field with magetic "south" at geographic "north".



6) A planar current loop has magnetic moment $\vec{\mu} = I\vec{A}$ where $\vec{A}$ is the area of the loop. $\vec{A}$ is perpendicular to the plane of the loop & found by a right hand rule. (Curl r.h. fingers in direction of current & thumb indicates direction of $\vec{A}$)



7) A magnetic dipole, $\vec{\mu}$, in a uniform magnetic field experiences no net force, but does experience a net torque, $\tau = \vec{\mu} \times \vec{B}$.

8) There is potential energy associated with the orientation of $\vec{\mu}$ in a $\vec{B}$ field, with $U_B = -\vec{\mu} \cdot \vec{B}$.

9) The Hall Effect is an expirement that can be used to determine the sign (+ or −) of moving charges in a current. Know how that experiment works.

10) Currents are sources of magnetic fields. If we know all the currents, we can calculate $\vec{B}$ using the Biot-Savart Law

$$d\vec{B} = \frac{\mu_0}{4\pi} \cdot I \frac{d\vec{s} \times \hat{r}}{r^2}$$

$\mu_0 = 4\pi \times 10^{-7}$ T m/Amp, $\vec{r}$ is vector from small current segment to location you are computing the $\vec{B}$ field.

11) Ampere's Law: $\oint_{\substack{\text{closed}\\\text{loop}}} \vec{B} \cdot d\vec{s} = \mu_0 I_{enclosed}$

- know how to use to compute $\vec{B}$ for
  - i) ∞ straight line current (or cylinder)
  - ii) solenoid
  - iii) toroid
  - iv) ∞ plane [think of this as a collection of ∞ straight line currents]

12) Parallel currents attract & opposite curent repel.

$\frac{\text{Force}}{\text{length}}$ on segments of two parallel wires

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

13) Know how to use Biot-Savaart to compute B for simple geometries: i) planar circular loop
- ii) straight line segment
- iii) combinations of (i) and (ii)

(this includes understanding how to find the direction of $\vec{B}$ using R.H.R. and symmetry arguments)

14) Faradays Law: $\text{EmF} = -\frac{d\Phi}{dt}$

where $\Phi = \oint_{\text{surface}} \vec{B} \cdot d\vec{A}$ = flux of $\vec{B}$

15) Know how to use Lenz's Law to find direction of induced currents for. i) motional emf

ii) changing B fields

16) Understand how changing $\vec{B}$ field cause $\vec{E}$ fields (even where there are no electric charges to cause currents)

- This E-field is really the source of the EmF.