Flipping Physics Lecture Notes:
Biot-Savart Law and Magnetic Field around a Current Carrying Wire
http://www.flippingphysics.com/biot-savart.html

The Biot-Savart law:

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

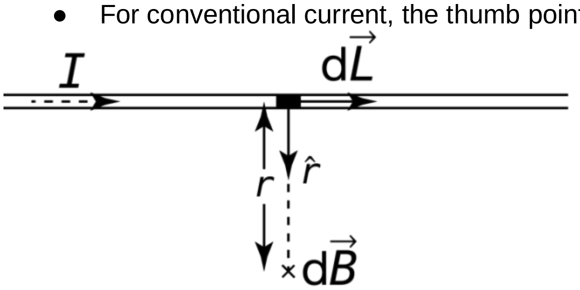
- This is an experimentally determined equation; you cannot derive it.
- Unit vector r is a position vector which points from the location of the infinitesimally small length of the wire, dL, to the location of the infinitesimally small magnetic field, dB.
  - r is the magnitude of the distance between those two points
- Magnetic permeability, μ, is the measurement of the amount of magnetization of a material in response to an external magnetic field. μ_0 is the magnetic permeability of free space:

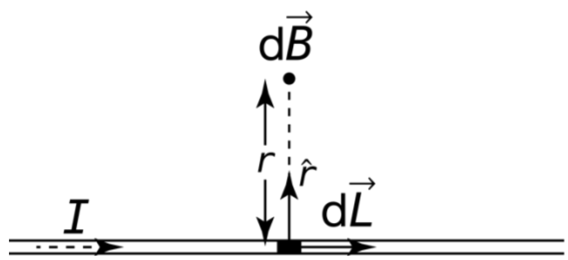
$$\mu_0 = 4\pi \times 10^{-7}\frac{T \cdot m}{A}$$

- This equation shows that a current carrying wire creates a magnetic field. In fact, because current is composed of individually moving electric charges, even a single moving electric charge causes a magnetic field.

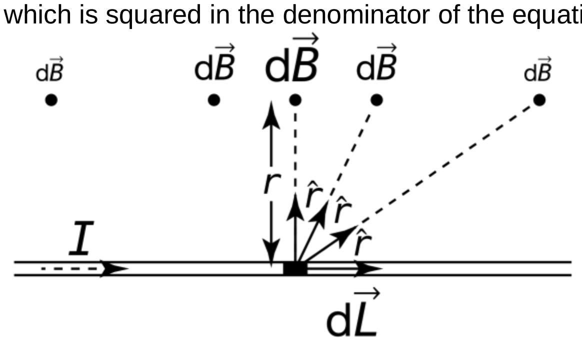
The direction of the magnetic field created by a current carrying wire can be seen using the Biot-Savart law. It is the cross product, so again, we use the right-hand rule!

- Fingers point in the direction of current/wire.
- Fingers curl in the direction of unit vector r.
- For conventional current, the thumb points in the direction of the magnetic field.

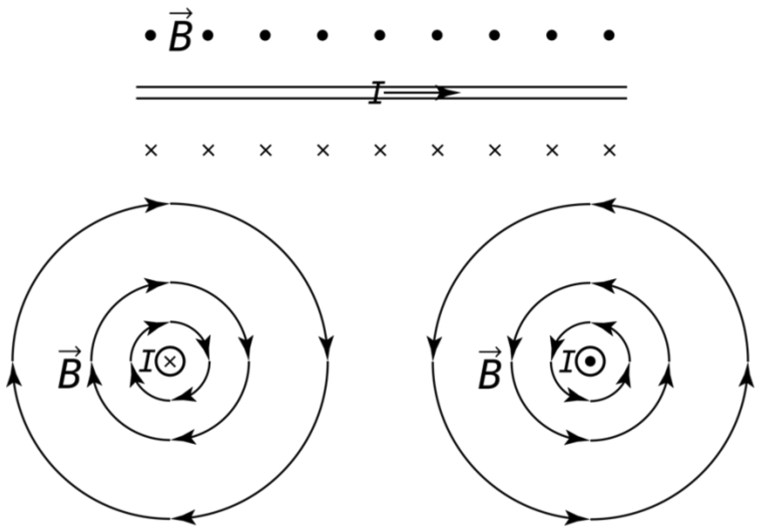




Notice the direction of the magnetic field caused by an infinitesimally small portion of the current carrying wire, dL, is the same along a line parallel to the straight wire, however, the magnitude of the magnetic field decreases as you get farther from a line perpendicular to the straight wire. The direction remains the same because the cross product of dL and unit vector r always gives the same direction. The magnitude decreases as the value of r, which is squared in the denominator of the equation, increases.



However, now realize that there are, for an infinitely long, straight, current carrying wire, an infinite number of dL's and all of their magnetic fields add up to cause the magnetic field to have a uniform value at a distance r straight out from the wire. And, the magnitude of the magnetic field decreases as r, the distance from the wire, increases.



- An alternate right-hand rule exclusively for the magnetic field which surrounds a current carrying wire is:
    - Point thumb in direction of current.
        - Fingers curl in the direction of the magnetic field.
- The Biot-Savart law can also be used to determine the magnitude of the magnetic field a distance r from an infinitely long, straight, current carrying wire. That equation is: $B = \frac{\mu_0 I}{2\pi r}$
    - We now know the magnetic field magnitude is inversely proportional to distance from the wire.