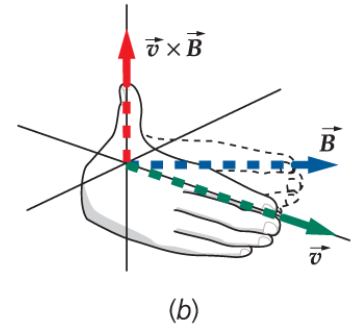


The Cross-Product Right Hand Rule

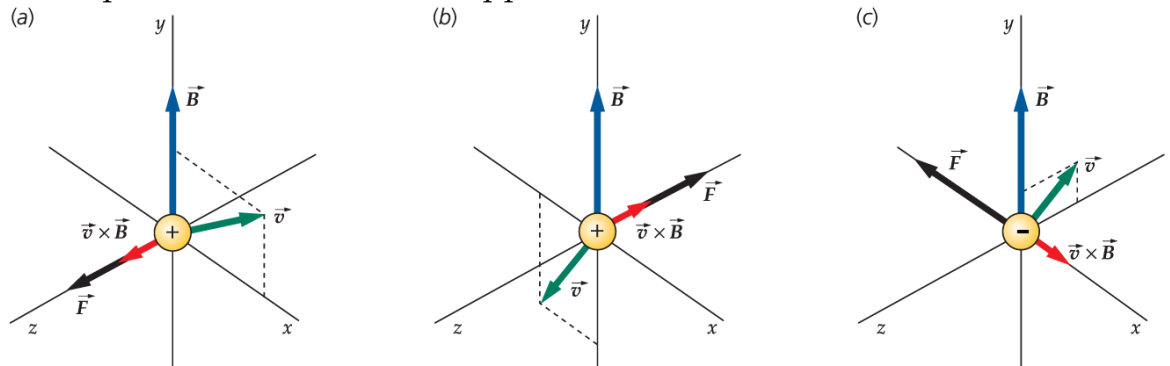
The magnetic force on a moving point charge in a magnetic field is given by $\vec{F} = q\vec{v} \times \vec{B}$. We will start by determining the direction of $\vec{v} \times \vec{B}$.

- 1) Point the fingers of your right hand in the direction of \vec{v} (the first vector in the cross-product).
- 2) Rotate your hand so that your fingers can be curled towards \vec{B} (the second vector in the cross-product).
- 3) Your thumb will point in the direction of $\vec{v} \times \vec{B}$.



Tipler & Mosca, *Physics for Scientists and Engineers*, 6e © 2008 W.H. Freeman and Company

For a positive charge ($q > 0$) the magnetic force \vec{F} will point in the same direction as $\vec{v} \times \vec{B}$. For a negative charge ($q < 0$) the magnetic force \vec{F} will point in the direction opposite $\vec{v} \times \vec{B}$.



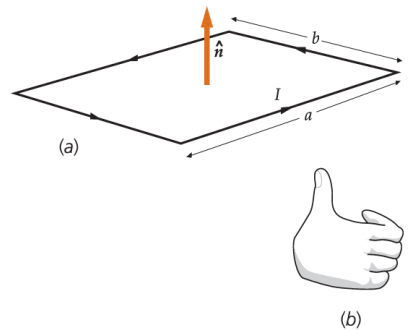
Tipler & Mosca, *Physics for Scientists and Engineers*, 6e © 2008 W.H. Freeman and Company

This right hand rule applies to all cross products: $\vec{F}_{\text{wire}} = I\vec{L} \times \vec{B}$, $\vec{B} = \frac{\mu_0}{4\pi} \frac{q\vec{v} \times \hat{r}}{r^2}$, $d\vec{B} = \frac{\mu_0}{4\pi} \frac{I d\vec{l} \times \hat{r}}{r^2}$, and $\vec{S} = \frac{\vec{E} \times \vec{B}}{\mu_0}$ are examples from this course. Point the fingers of your right hand along the direction of the first vector and then curl your fingers toward the second vector; your thumb will give the direction of the cross product. If the equation has a q , then for a negative charge you will multiply your cross-product by a negative scalar which reverses its direction.

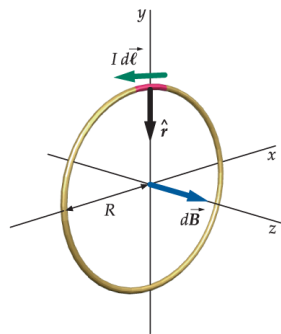
The Curled Fingers Right Hand Rule

There is a second use of the right hand rule, in which a circular direction in some plane (clockwise or counter-clockwise) needs to be related to a direction perpendicular to that plane. In all of these you will curl the fingers of your right hand in the circular direction; your thumb then gives the appropriate direction perpendicular to the plane.

When current is flowing around a loop, curl your fingers in the direction of the current. Your thumb will give the direction of \hat{n} , the normal unit vector for that loop. This will also be the direction of $\vec{\mu} = NIA\hat{n}$, the magnetic dipole moment created by the loop.



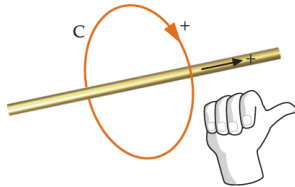
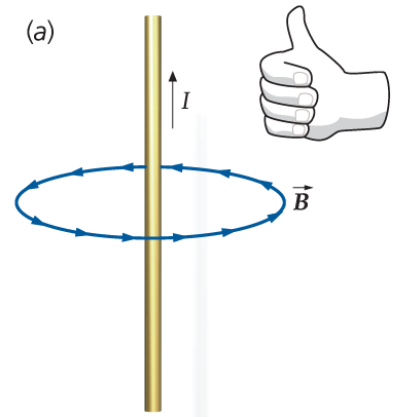
Tipler & Mosca, *Physics for Scientists and Engineers*,
6e © 2008 W.H. Freeman and Company



Tipler & Mosca, *Physics for Scientists and Engineers*
and *Engineers*, 6e © 2008 W.H. Freeman and
Company

The magnetic field at the center of a circular loop of radius R carrying a current I is $B = \frac{\mu_0 I}{2R}$. Curl your right fingers along the direction of the current. Your thumb will give the direction of the magnetic field created by this current at the center of the loop.

An infinitely long straight wire carrying a current I will create a magnetic field at a point that is a distance R away from the wire given by $B = \frac{\mu_0 2I}{4\pi R}$. Point your right thumb in the direction of the current and your fingers will curl in the direction of the magnetic field.



Tipler & Mosca, *Physics for Scientists and Engineers*, 6e © 2008 W.H. Freeman and Company

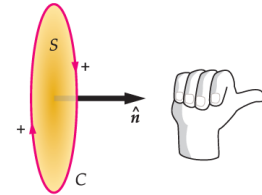
Ampere's Law states that $\oint_C \vec{B} \cdot d\vec{l} = \mu_0 I_C$. When using this equation you will integrate around a closed loop. Curl your right fingers in the direction of integration. Your right thumb will then give the direction of current passing through the loop that would be defined as positive. (Current going the other way would be considered negative.)

The induced nonconservative electric field for a stationary circuit in a changing magnetic field is given by

$$\mathcal{E} = \oint_C \vec{E}_{\text{nc}} \cdot d\vec{l} = -\frac{d}{dt} \int_S \vec{B} \cdot \hat{n} dA = -\frac{d\phi_m}{dt}$$

If you point your right thumb in the direction defined as \hat{n} for integrating to find the magnetic flux, your fingers will curl in the direction of integration for the line integral of the nonconservative electric field.

Similarly, the generalized form of Ampere's Law states that $\oint_C \vec{B} \cdot d\vec{l} = \mu_0 I + \mu_0 \epsilon_0 \frac{d\phi_e}{dt}$. If you point your right thumb in the direction defined as \hat{n} for integrating to find the electric flux, your fingers will curl in the direction of integration for the line integral of the magnetic field.



Tipler & Mosca, *Physics for Scientists and Engineers*, 6e © 2008 W.H. Freeman and Company