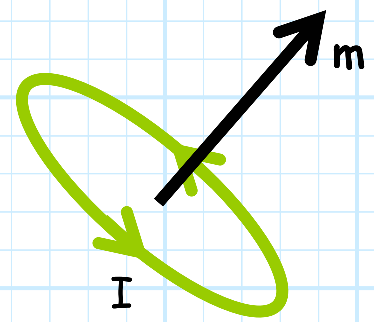
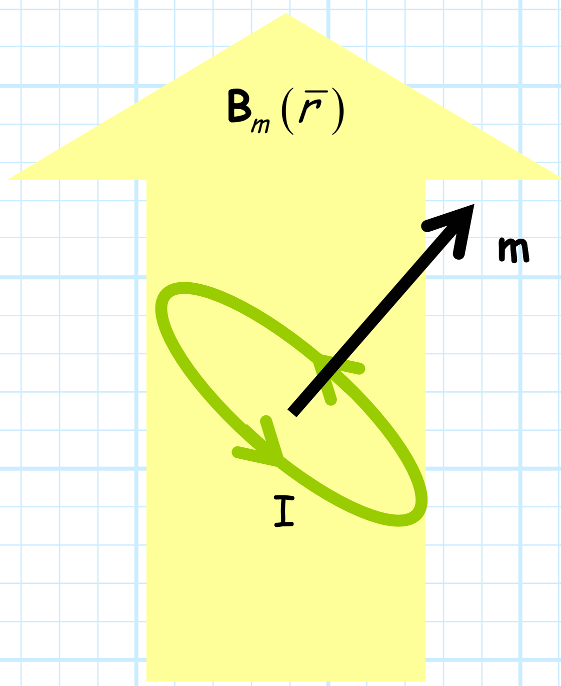
The Magnetic Dipole in a B-field

Consider the case of an **arbitrarily aligned** magnetic dipole:



Say this dipole is **immersed** in some field $\mathbf{B}_m(\bar{r})$:



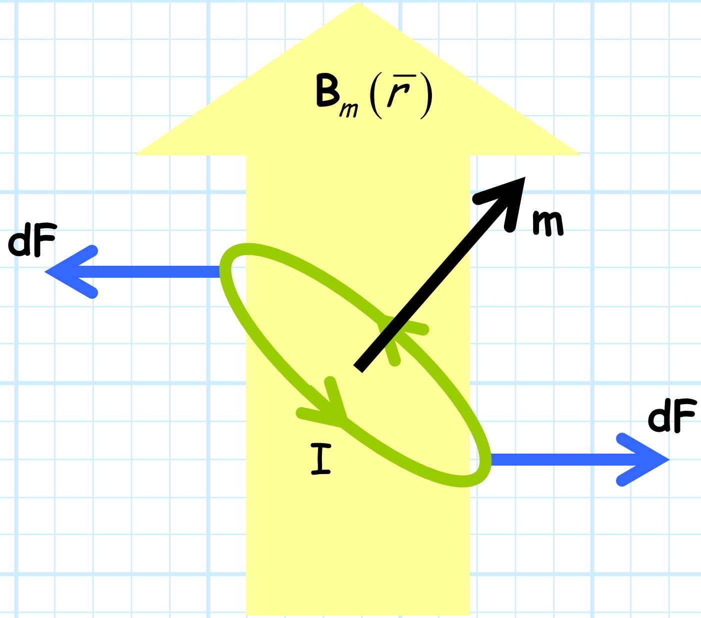
Q: *What happens to a **magnetic dipole** when exposed to a magnetic flux density* $\mathbf{B}_m(\bar{r})$*?*

A: Exactly what the **Lorentz Force equation** says will happen!

Recall that the force **dF** on some current element $I\,\overline{d\ell}$ is:

$$\mathbf{dF} = I\,\overline{d\ell} \times \mathbf{B}_m(\bar{r})$$

Note this force is therefore **perpendicular** to **both** $\mathbf{B}(\bar{r})$ and current I.

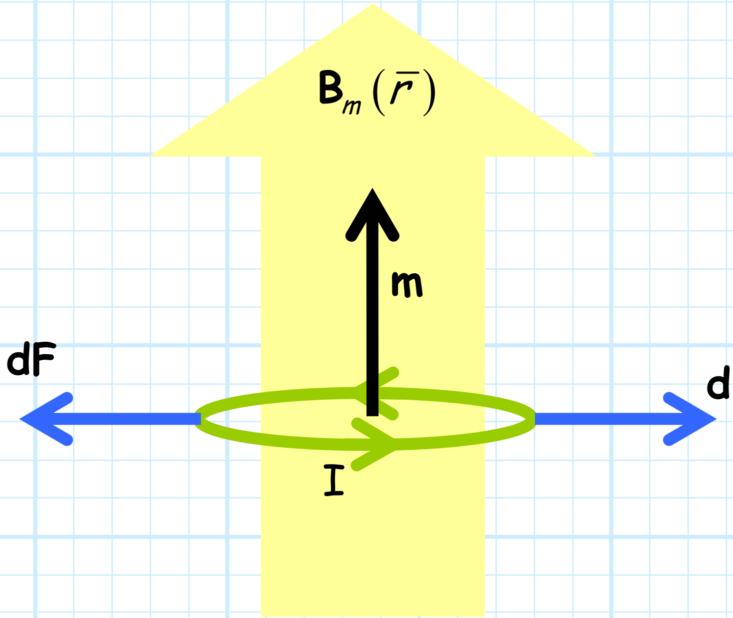


The total **resultant** force on a current loop is will be **zero**, so the dipole does **not** change position. I.E.:

$$\oint_C I\,\overline{d\ell} \times \mathbf{B}_m(\bar{r}) = 0$$

However, the forces on the current do apply a **torque** $\mathbf{T}_m$ to the current loop!

The current loop (i.e., magnetic dipole) will **rotate** until the dipole moment **m** is aligned with the magnetic flux density vector $\mathbf{B}_m(\bar{r})$.



For a **circular** current loop, it can be shown (pp. 234-235) that the torque applied is:

$$\mathbf{T}_m = \mathbf{m} \times \mathbf{B}(\bar{r}) \qquad [N \cdot m]$$

Note that once the magnetic dipole moment **m** is aligned with magnetic flux density $\mathbf{B}(\bar{r})$, the torque $\mathbf{T}_m$ is equal to **zero**—the magnetic dipole **stops rotating** and **remains aligned** with $\mathbf{B}(\bar{r})$.