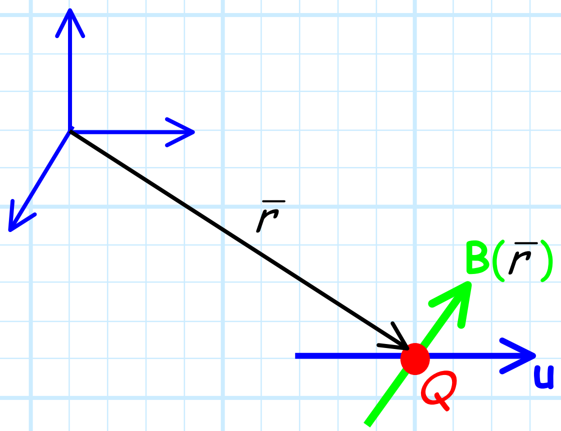
The Magnetic Force

Say a **charge** Q is located at some **point** in space (denoted by position vector $\bar{r}$), and is moving with velocity $\mathbf{u}$.

Likewise, there exists **everywhere** in space a magnetic flux density (we neither know nor care **how** this field was **created**).

The value (both magnitude and direction) of the magnetic flux density vector **at point** $\bar{r}$ is $\mathbf{B}(\bar{r})$:

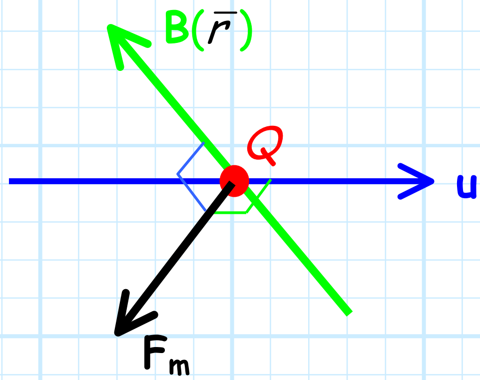


Q: *Our "**field theory**" of electromagnetics says that the magnetic flux density will apply a **force** on the moving charge (i.e., **current**). Precisely what **is** this force (i.e., its magnitude and direction)?*

A: The answer is not **quite** as simple the electric force equation. The **force** $\mathbf{F}_m$ on charge Q moving at velocity $\mathbf{u}$ is :

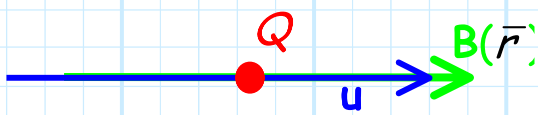
$$\mathbf{F}_m = Q\,\mathbf{u} \times \mathbf{B}(\bar{r})$$

Note therefore, that the resulting force $\mathbf{F}_m$ will be **orthogonal** to both the **velocity** vector **u** and the **magnetic flux density** vector $\mathbf{B}(\bar{r})$. E.G.,:



Note the **maximum** force is applied when the magnetic flux density vector is **orthogonal** to the velocity vector (i.e., $\theta = 90^\circ$).

Alternatively, the force on the charge will actually be **zero** if the magnetic flux density is **parallel** to the velocity vector (i.e., $\theta = 0^\circ$) :



$\mathbf{F}_m = 0$

Note there is **no** equivalent situation for the **electric** force—the only way $\mathbf{F}_e$ can be zero is **if** the electric field $\mathbf{E}(\bar{r})$ is **zero**!