Electromagnetics:
Electromagnetic Field Theory

Lorentz Force Law

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Lorentz Force Law

$$\vec{F} = \underbrace{Q\vec{E}}_{} + \underbrace{Q\vec{u} \times \vec{B}}_{}$$

Electrostatic Force

$$\vec{F}_e = Q\vec{E}$$

- Force $\vec{F}_e$ in same direction as $\vec{E}$.
- Force is independent of velocity.
- Can change velocity of the charge.
- $\vec{F}_e$ is usually much greater than $\vec{F}_m$ except at very high velocity.

Magnetostatic Force

$$\vec{F}_m = Q\vec{u} \times \vec{B}$$

- Force $\vec{F}_m$ is perpendicular to $\vec{B}$ and velocity $\vec{u}$.
- Force is only exerted on moving charges.
- Force is zero if velocity is in same direction as the magnetic flux.
- Cannot change kinetic energy of the charge (i.e. $\vec{F}_m \cdot d\vec{\ell} = 0$).
- Magnetic field can only change the direction of velocity.

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Recall $\vec{F} = m\vec{a}$

$$\vec{F} = m\frac{d\vec{u}}{dt} = Q\vec{E} + Q\vec{u}\times\vec{B}$$

This equation is used to calculate total force on a charge as well as its position, velocity, and acceleration.

$$\vec{x}(t) \equiv \text{position}$$
$$\frac{d}{dt}\vec{x}(t) \equiv \text{velocity}$$
$$\frac{d^2}{dt^2}\vec{x}(t) \equiv \text{acceleration}$$
$$\frac{d^3}{dt^3}\vec{x}(t) \equiv \text{jerk}$$
$$\frac{d^4}{dt^4}\vec{x}(t) \equiv \text{snap}$$
$$\frac{d^5}{dt^5}\vec{x}(t) \equiv \text{crackle}$$
$$\frac{d^6}{dt^6}\vec{x}(t) \equiv \text{pop}$$

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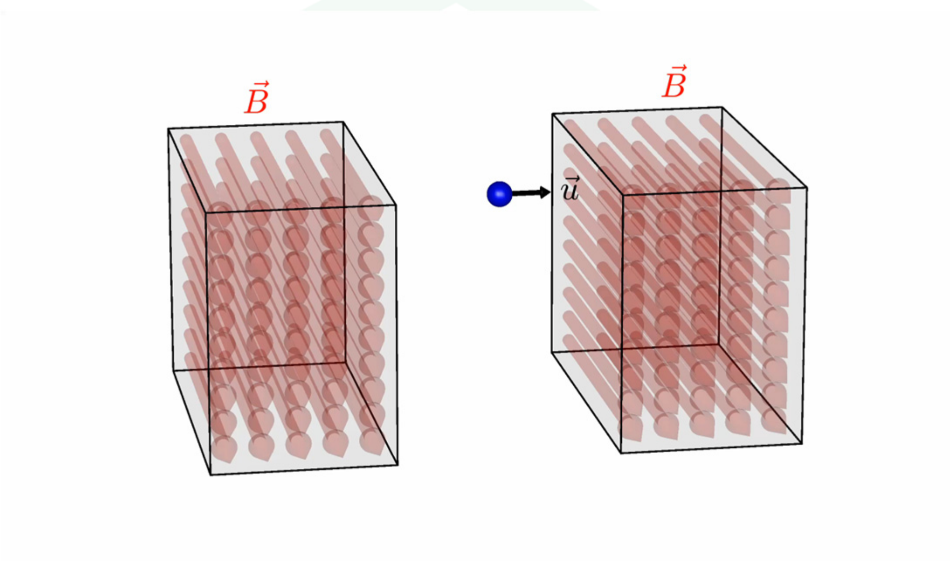
Animation of Magnetic Force



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