Electric and Magnetic Fields

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Contents

Constants and Units

We follow the SI system of units.
ϵ_0 and μ_0 are constants determined from experiments.

$$\epsilon_0 = 8.85 \times 10^{-12}\text{Coulomb}^2/\text{Nm}^2$$
$$1/4\pi\epsilon_0 = 9.0 \times 10^9\text{Nm}^2/\text{Coulomb}^2$$
$$\mu_0 = 4\pi \times 10^{-7}\text{Weber}/(\text{amp} \cdot \text{m})$$
$$\mu_0/4\pi = 10^{-7}\text{Weber}/(\text{amp}\,\text{m})$$

unit of charge = Coulomb
unit of current = Coulomb/seconds = ampere
ρ = charge density = charge per unit volume
$\bar{j}$ = current density = current per unit volume
Weber = unit for flux of $\bar{B}$

Defining $\bar{E}$ and $\bar{B}$

If a small test charge q is placed at a point and if the force on the charge is $\bar{F}$, then the electric field $\bar{E}$ is defined to be

$$\bar{E} = \bar{F}/q$$

where q is positive.
unit of $\bar{E}$ = $[\bar{E}]$=Newton/Coulomb
The test charge must be very small so that it doesn't modify the electric field too much.

The magnetic force on a moving charge depends on the direction of velocity;
1.Force is zero when $\bar{v}$ is parallel to $\bar{B}$

2.Force is maximum when $\bar{v}$ is perpendicular to $\bar{B}$

$$\bar{B} = F_{\perp}/q_0\bar{v}$$

Unit of $\bar{B} = [\bar{B}]\frac{\text{N}}{\text{Coulomb}/(\text{m/s})} = \text{N}/(\text{amp/m}) = \text{Weber/m}^2$
1 Tesla $= \text{Weber/m}^2 = 10^4$ Gauss

How are the electric and magnetic fields produced?

The electric field is produced by charges and the magnetic field is produced by currents. This is not the only way the fields are produced. There are many other ways the fields can be produced.