PH5

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1 Electromagnetism

Electromagnetism is all to do with fields. A field is a load of numbers. Vector fields are the best fields, and all the rest suck, so we only care about vector fields. A uniform field is a field where all the vectors are parallel. In a uniform electric field there is half the potential difference halfway between the poles, that is to say

$$E = V/d$$

When working with diagrams describing a magnetic field, current traveling into the the page is expressed by a small circle with a cross inside it. Current traveling out of the page can be shown by a small circle witha dot in its centre.

The "right hand rule" (holding one's hand in a "thumbs up" position) can tell the the dirction of a rotating magnetic field (one's fingers) around a wire carrying a cur rent in a certain direction (your thumb). The "left hand rule" (holding a thumbs up position then pointing the index finger and pointing the middle finger perpendicular to the palm) tells you the direction of the direction of **m**ovement of a wire (thu**m**b) with a magnetic **f**ield (**f**irst finger) and **c**urrent (se**c**ond finger).

The magnitude of an electric field can be defined as the ratio of force to the relevant property. In this case, current and length of conductor. The angle of the wire in the field also affects the force, and hence can be described thus:

$$F = BIL\sin(\theta)$$

where the units of B are $NA^{-1}m^{-1} \equiv T$

1.1 The Magnetic Field of an Infinitely Long Conductor

Generally,

$$\mathrm{d}B = \frac{\mu_0 i \sin\theta \mathrm{d}s}{4\pi r^2}$$

Confining this to a plane perpendicular to the current eliminates θ, giving

$$\mathrm{d}B = \frac{\mu_0 i \mathrm{d}s}{4\pi r^2}$$

hence

$$B = \frac{\mu_0}{4\pi}\int_0^\infty \frac{R\mathrm{d}s}{(s^2+R^2)^{\frac{3}{2}}} = \frac{\mu_0 I}{2\pi R}\left[\frac{S}{(s^2+R^2)^{\frac{1}{2}}}\right]_0^\infty = \frac{\mu_0 I}{2\pi R}$$

giving the magnetic flux density of the field created by a current in an infinitely long conductor in a plane perpendicular to the current.

1.2 Capacitors

Capacitors are a way to store energy/charge. The energy is stored in the electric field inbetween the two plates.

$$C = \frac{Q}{V} = \frac{\epsilon A}{d}$$

and

$$W = \frac{1}{2}QV = \frac{1}{2}CV^2$$

where

- C is capacitance
- Q is charge
- V is potential difference
- ϵ is the permiativity of free space
- A is the area of the plates
- d is the distance between the plates
- W is the energy stored in the field between the plates

For capacitors in parallel,

$$C = \sum_{i=1}^{n} c_i$$

whereas, for capacitors in series,

$$\frac{1}{C} = \sum_{i=1}^{n} \frac{1}{c_i}$$

Regarding discharging capacitors,

$$V = V_0 e^{-\frac{t}{RC}}$$

$$Q = Q_0 e^{-\frac{t}{RC}}$$

and

$$I = I_0 e^{-\frac{t}{RC}}$$

1.3 Solenoids

A solenoid is a coil of wire. The magnetic flux density B around a solenoid with n coils carrying a current I through a length l of wire is given by

$$B = \mu_0 I n$$

where $n > \frac{1}{\pi}$.

1.4 Root Mean Square

$$V = A \sin(\omega t)$$

$$V^2 = A^2 \sin^2(\omega t)$$

$$\bar{V}^2 = \frac{V^2}{2} = \frac{A^2}{2}$$

$$\bar{V} = \frac{V}{\sqrt{2}}$$

$$\bar{V} = I \times R$$

$\bar{V}$ may be written as V_{rms}

$$\bar{P} = \bar{V} \times I$$

Don't always use root mean square though, for things like fuses use the peak value.

2 Radioactivity

Nuclear radiation mostly comes in three types; alpha, beta and gamma. Alpha radiation can be distinguished because it will be blocked by pretty much anything vaguely substantial. Beta can be distinguised because it can bent with magnets. Gamma is bauss.