1 Magnetism

1.1 Formulas

Magnetic force on a moving charge: $F = qvB\sin\theta$

Magnetic force on a current carrying wire: $F = BIl\sin\theta$

Magnetic moment of a current carrying coil of N turns: $\mu = NIA$

Torque on a current carrying coil: $\tau = \mu B\sin\theta$

Radius of uniform circular motion of a charged particle in a magnetic field: $r = \frac{mv}{qB}$

Magnetic field of a long straight wire: $B = \frac{\mu_0 I}{2\pi r}$

Ampere's Law: $\sum B_{\parallel}\Delta l = \mu_0 I$

Magnetic force between two parallel wires: $\frac{F}{l} = \frac{\mu_0 I_1 I_2}{2\pi d}$

Magnetic field at the center of a circular coil: $B = \frac{\mu_0 I}{2r}$

Magnetic field inside a solenoid: $B = \mu_0 nI = \mu_0 NI/l$

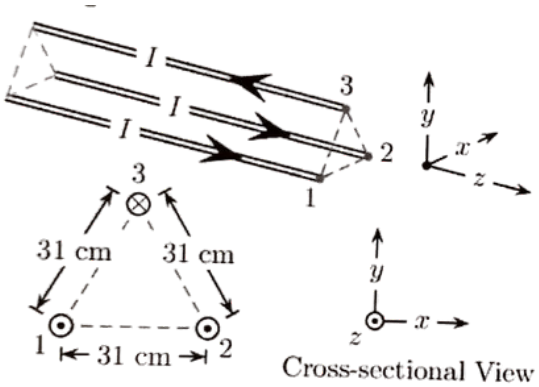
1.2 Electron Orbiting Hydrogen Atom Problem

In Niels Bohr's 1913 model of the hydrogen atom, and electron circles the proton at a distance of 8.24×10^{-11} m with a speed of 9.16×10^{5} m/s. The permeability of free space is 1.25664×10^{-6} T· m/A.

Compute the magnetic field strength that this motion produces at the location of the proton. Answer in units of T.

1.3 Three Parallel Wires Problem

Three very long wires are strung parallel to each other as shown in the figure below. Each wire is at a distance 31 cm from the other two, and each wire carries a current of magnitude $I = 3.3$ A in the directions shown in the figure.



Find the magnitude of the net force per unit length exerted on the upper wire (wire 3) by the other two wires. Answer in units of N/m.

1.4 Energy of Undeflected Electron Problem

The charge on an electron is 1.60218×10^{-19} C and its mass is 9.10939×10^{-31} kg.

What is the kinetic energy of an electron that passes undeviated through perpendicular electric and magnetic fields if $E = 0.23$ kV/m and $B = 1.5$ mT? Answer in units of eV.

1.5 Torque on Circular Loop Problem

A circular loop of radius 3.82 cm contains 64 turns of tightly wound wire.

If the current in the windings is 0.328 A and a constant magnetic field of 0.384 T makes an angle of 66° with a vector perpendicular with the loop, what torque acts on the loop? Answer in units of N·m.

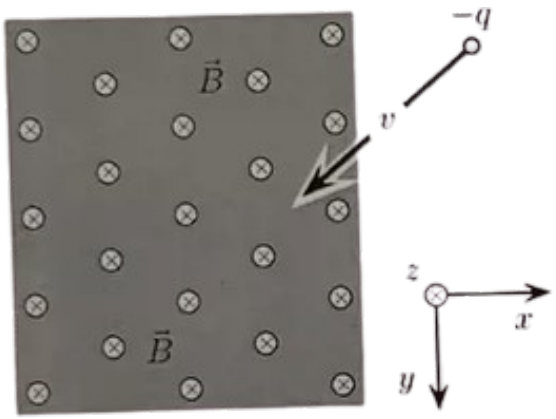
1.6 Dropped Steel Beam Problem

A 8.97 m long steel beam is accidentally dropped by a construction crane from a height of 12.3 m. The horizontal component of the Earth's magnetic field over the region is 23.3 μT. The acceleration of gravity is 9.8 m/s^2.

What is the induced emf in the beam just before impact with the Earth, assuming its long dimension remains in a horizontal plane, oriented perpendicularly to the horizontal component of the Earth's magnetic field? Answer in units of mV.

1.7 Right Hand Rule Problems

A negatively charged particle moving at 45° angles to both the x-axis and y-axis enters a magnetic field (pointing into of the page), as shown. $\hat{i}$ is in the x-direction, $\hat{j}$ is in the y-direction, and $\hat{k}$ is in the z-direction.



What is the initial direction of deflection?