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2. Compare the magnitudes of the electric and magnetic forces on an **electron** that has attained a velocity of 10^7 m/s. Assume an electric field intensity of 10^5 V/m, and a magnetic flux density associated with that of the Earth's magnetic field in temperate latitudes, 0.5 gauss. (Hints: 1. Review previous lecture notes to get the charge of electron; 2. Google the relationship between gauss and tesla as two units for the magnetic flux density.)

1. $e = 1.6\times10^{-19}\,C$
2. $1\ \text{gauss} = 10^{-4}\ \text{Tesla}$

Electric force

$$F_e = eE = 1.6\times10^{-14}\ N$$

Magnetic force

$$F_m = evB = 8.01\times10^{-17} N$$

Thus

$$\frac{F_e}{F_m} \approx 200$$

3. A point charge for which $Q = 2\times10^{-16}$ C and $m = 5\times10^{-26}$ kg is moving in the combined fields $\mathbf{E}=100\mathbf{a}_x-200\mathbf{a}_y+300\mathbf{a}_z$ V/m and $\mathbf{B}=-3\mathbf{a}_x+2\mathbf{a}_y-\mathbf{a}_z$ mT. If the charge velocity at t = 0 is $\mathbf{v}(0) = (2\mathbf{a}_x-3\mathbf{a}_y-4\mathbf{a}_z)10^5$ m/s (a) give the unit vector showing the direction in which the charge is accelerating at t =0; (b) find the kinetic energy of the charge at t =0.

(a) Force excerted on the charge

$$\vec{F} = Q(\vec{E} + \vec{v}\times\vec{B})$$
$$= 24\times10^{-14}\vec{a}_x + 24\times10^{-14}\vec{a}_y - 4\times10^{-14}\vec{a}_z\ N$$

Therefore

$$\vec{a} = \frac{\vec{F}}{m} = 4.8\times10^{12}\vec{a}_x + 4.8\times10^{12}\vec{a}_y + 8\times10^{11}\vec{a}_z\ m/s^2$$

Unit vector

$$\vec{a}_F = \frac{\vec{a}}{|\vec{a}|} = 0.702\vec{a}_x + 0.702\vec{a}_y - 0.117\vec{a}_z$$

(b) Kinetic energy, $v \sim 10^6 m/s \ll 3\times10^8 m/s$

$$E = \frac{1}{2}mv^2 = 7.25\times10^{-15}\ J$$

4. A solenoid is 25 cm long, 3 cm in diameter, and carries 4 A dc in its 400 turns. Its axis is perpendicular to a uniform magnetic field of 0.8 Wb/m^2 in air. **Using an origin at the center of the solenoid**, calculate the torque acting on it.

For each turn, torque is

$$\tau = |\vec{m} \times \vec{B}|$$

$$= \frac{\pi d^2}{4} \cdot I \cdot B_0$$

Same direction

$$\Rightarrow \quad N = 400\tau = 0.9 \text{ N}\cdot\text{m}$$

perpendicular to the plane formed by $\vec{B_0}$ and the axis of the solenoid

5. A toroidal core has a rectangular cross section defined by the surfaces ρ= 2 cm, ρ= 3 cm, z = 4 cm, and z = 4.5 cm. The core material has a relative permeability of 80. If the core is wound with a coil containing 8000 turns of wire, find its inductance.

Ampere's loop principle

$$H \cdot 2\pi\rho = N \cdot I \quad \Rightarrow \quad H = \frac{NI}{2\pi\rho}$$

Then

$$\Phi = \iint N \mu_r \mu_0 H \, dS = \frac{\mu_0 \mu_r N^2 I}{2\pi} h \ln \frac{\rho_2}{\rho_1}$$

$$\Rightarrow \quad L = \frac{\Phi}{I} = 2.076 \text{ H}$$