UNIVERSIDADE da MADEIRA

Electromagnetism

Series of problems 5

1. The point charge $Q = 18\,\mathrm{nC}$ has a velocity of $5 \times 10^6\,\mathrm{m\,s^{-1}}$ in the direction $\mathbf{a}_v = 0.04\mathbf{a}_x - 0.05\mathbf{a}_y + 0.2\mathbf{a}_z$. Calculate the magnitude of the force exerted on the charge by the field:

   (a) $\mathbf{B} = -3\mathbf{a}_x + 4\mathbf{a}_y + 6\mathbf{a}_z\,\mathrm{mT}$.

   (b) $\mathbf{E} = -3\mathbf{a}_x + 4\mathbf{a}_y + 6\mathbf{a}_z\,\mathrm{kV/m}$.

   (c) $\mathbf{B}$ and $\mathbf{E}$ acting together.

2. Find the instantaneous acceleration of an electron moving at a speed of $1.0 \times 10^7\,\mathrm{m/s}$ in the xy plane at an angle of $30\,^\circ$ to the y axis. A uniform magnetic field of magnitude $10\,\mathrm{T}$ is acting in the positive y-axis direction.

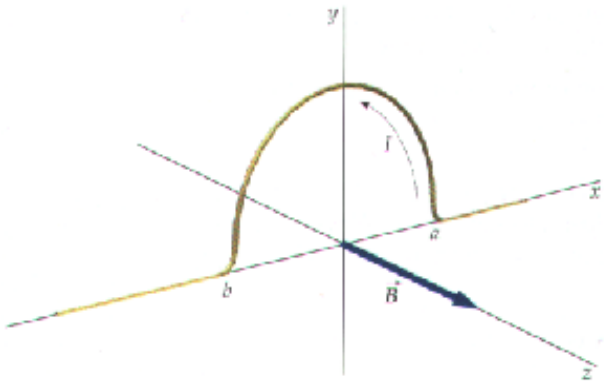
3. An electron in a television cathode-ray tube moves toward the front of the tube at a speed of $8.0 \times 10^6\,\mathrm{m/s}$ along the x axis. Around the tube there is a wire winding that creates a magnetic field of magnitude $0.025\,\mathrm{T}$; this field is directed at an angle of $60\,^\circ$ to the x axis and lies in the xy plane.

   (a) Calculate the value of the magnetic force to which the electron is subjected.

   (b) Find a vector expression for the magnetic force to which the electron is subjected.

4. A wire $3\,\mathrm{mm}$ long carries a current of $3\,\mathrm{A}$ in the x direction. The wire is in a magnetic field of magnitude $0.02\,\mathrm{T}$ which is in the xy plane and which is directed at an angle of $30\,^\circ$ to the x axis. What is the magnetic force exerted on the wire segment?

5. A wire bent in a semicircular loop of radius R is in the xy plane and carries a current I from point a to point b, as shown in the figure. There is a uniform magnetic field $\mathbf{B} = B\mathbf{k}$ perpendicular to the loop plane. Find the force acting on the semicircular loop of the wire.



6. A straight horizontal copper wire has a current $i = 28\,\mathrm{A}$ passing through it. What is the magnitude and direction of the minimum required magnetic field, $\mathbf{B}$, for the wire to be suspended, i.e. to counterbalance the gravitational force exerted on it? Note: the linear density of the wire is $46,6\,\mathrm{g/m}$.

7. Consider the field $\mathbf{B} = -2\mathbf{a}_x + 3\mathbf{a}_y + 4\mathbf{a}_z\,\mathrm{mT}$ in free space. Find the force (in vector form) that is exerted on a straight wire that carries a current of $12\,\mathrm{A}$ in the direction of $\mathbf{a}_{AB}$, where $A\,(1,1,1)$ and:

   (a) $B\,(2,1,1)$.

   (b) $B\,(3,5,6)$.

Solutions:
1a) $592,0\,\mu$N; 1b) $140,6\,\mu$N; 1c) $608,3\,\mu$N; 2) $\mathbf{a} = (0, 0, -8.8 \times 10^{18})\ \mathrm{m/s^2}$; 3a) $F_B = 2.8 \times 10^{-14}\,\mathrm{N}$; 3b) $\mathbf{F}_B = (0; 0; -2.8 \times 10^{-14})$ N; 4) $\mathbf{F} = (0; 0; 9 \times 10^{-5})$ N; 5) $\mathbf{F} = 2IRB\hat{\jmath}$; 6) $B = 1,6 \times 10^{-2}\,\mathrm{T}$; $\mathbf{B}$ is $\perp$ to both the wire and the gravitational force; 7a) $\mathbf{F} = (0; -48; 36)$ mN; 7b) $\mathbf{F} = (12; -216; 168)$ mN.