Chapter 27 Homework

Magnetic Field and Magnetic Forces on Charged Particles

Qu. 1 A charged particle enters a uniform magnetic field and follows the circular path shown in the figure.

\[ ... \]

a) Is the particle positively or negatively charged? (Ans: Positive)

b) Find the centripetal force if the particles speed is \(1 \times 10^5\) m/s, the radius of the path is 1 km and the particle is a proton with a mass \(1.67 \times 10^{-27}\) kg. (Ans: \(F = 1.67 \times 10^{-20}\) N)

c) Find the B-field if the charge is \(1.6 \times 10^{-19}\) C. (Ans: \(B = 1 \times 10^{-6}\) T)

Qu. 2 A particle with a charge of 8.4 \(\mu\)C and a speed of 45 m/s enters a uniform magnetic field whose magnitude is 0.3 T. For each of the cases depicted in the drawing find the magnitude and direction of the magnetic force on the particle.

\[ ... \]
Magnetic Field and Magnetic Forces on Current Carrying Conductors

Qu. 3 A conducting bar with mass, m and length, L slides over horizontal rails that are connected to a voltage source. The voltage maintains a constant current, I in the rails and bar, and a constant, uniform, vertical magnetic field B fills the region between the rails.

a) Find the magnitude and direction of the net force on the conducting bar. Ignore friction, air resistance, and electrical resistance. (see diagram)

b) If the bar has a mass, m find the distance d that the bar must move along the rails from rest to attain a speed v.  
   \[
   \text{(Ans: } d = \frac{v^2 m}{2 B i L}).
   \]

c) It has been suggested that such rail guns based on this principle could accelerate payloads into Earth orbit or beyond. Find the distance the bar must travel along the rails it is to reach the escape velocity for the Earth, 11 km/s. Let B = 0.5 T, I = 2 \times 10^3 A, m = 25 kg, and L = 0.5m.  
   \[
   \text{(Ans: } d = 3025 \text{ km}).
   \]

Qu. 4 A square coil of wire containing a single turn is placed in a uniform 0.25 T magnetic field. Each side has a length of 0.32 m and the current in the coil is 12 A. Determine the magnitude and the direction of the force on each of the four sides.

\[
\begin{align*}
\text{I} & \\
& \\
& \\
\text{B} & \\
& \\
& \\
& \\
\end{align*}
\]

a) 0.96 N out of the page for the right hand side of the loop 

b) 0.96 N into the page for left hand side of the loop 

c) zero force on the top and bottom sides
Qu. 5 Current of 5 A flows in a circular loop of radius 2 cm. The normal to the loop is 60° to a uniform field of 0.06 T. What is the magnitude of the torque of the loop? (Ans: 3.26 x 10^-4 Nm)

Charged Particles Moving in B and E Fields

Qu. 6 In a Bainbridge mass spectrometer, ions pass through the crossed E and B₁ field of a velocity selector and are then deflected by a magnetic field B₂. Given that E = 3 x 10^5 V/m and B₁ = B₂ = 0.4 T, calculate the difference in position on the photographic plate for singly charged ions of the Carbon isotopes with masses 12u and 14u. (Ans: 7.78 cm)

Qu. 7 A charged particle is accelerated from rest along the x-axis by a potential difference of 225 V and then enters a uniform field \( B = 10 \, \text{G} \, \hat{k} \). The radius of the path is 5 cm. What is the charge to mass ratio of the particle? (Ans: 1.8 x 10^{11} \, \text{C/kg})

Vector Cross Products

Qu. 8 A particle with a charge of -1.24 x 10^{-8} \, \text{C} is moving with an instantaneous velocity \( \mathbf{v} = (4.19 \times 10^4 \, \text{m/s}) \, \hat{i} + (-3.85 \times 10^4 \, \text{m/s}) \, \hat{j} \). What is the force exerted on the particle by a magnetic field

a) \( \mathbf{B} = 1.4 \, \text{T} \, \hat{i} \)  
(Ans: \( \mathbf{F} = -6.68 \times 10^{-4} \, \text{N} \, \hat{k} \) )

b) \( \mathbf{B} = 1.4 \, \text{T} \, \hat{k} \)  
(Ans: \( \mathbf{F} = 6.68 \times 10^{-4} \, \text{N} \, \hat{i} + 7.27 \times 10^{-4} \, \text{N} \, \hat{j} \) )

Qu. 9 A particle with charge – 5.6 nC is moving in a uniform magnetic field \( \mathbf{B} = -1.25 \, \text{T} \, \hat{k} \). The magnetic force on the particle is measured to be \( \mathbf{F} = (-3.4 \times 10^{-7} \, \text{N}) \, \hat{i} + (7.4 \times 10^{-7} \, \text{N}) \, \hat{j} \). Calculate the components of the velocity of the particle. 
(Ans: \( v_x = -105.71 \, \text{m/s}, v_y = -48.57, \, v_z \) is indeterminate.)