

Physics 111 Homework Solutions Week #4 - Friday

Tuesday, January 28, 2014

Chapter 17

Questions

- None

Multiple-Choice

- None

Problems

- None

Wednesday, January 29, 2014

Chapter 17

Questions

- 17.2 Not true in general since $F = 0$ if v is parallel to B for example. If F is non-zero, then it will be proportional to B .
- 17.5 a. The initial force is along z and the particle will travel in a circle in the x - z plane in the positive z portion.
b. Since v and B are parallel there is no force and the particle will continue moving along the x -axis at constant v
c. The particle will travel in a helix along the B field direction (x -axis) since the component of v along the x -axis is unchanged. The initial component of v along the y axis will result in a force along the negative z axis and so the particle will travel in a “circle in the y - z plane, below the z -axis” while traveling at constant speed along the x -axis, resulting in a net helical motion.
- 17.7 Assuming a positive charge,
a. F is into the paper
b. F is up out of the paper
c. v is up out of the paper

Multiple-Choice

- 17.2 C
17.3 B
17.5 B
17.6 D

Problems

- 17.1 The magnetic force is $3.0 \times 10^{-12} \text{ N}$, and this gives for a velocity in a 30 T field, from

$$F = qvB \rightarrow v = \frac{F}{qB} = \frac{3.0 \times 10^{-12} \text{ N}}{1.6 \times 10^{-19} \text{ C} \times 30 \text{ T}} = 6.25 \times 10^5 \frac{\text{m}}{\text{s}}.$$

17.2. The magnetic force is given as

$F = qvB \sin \theta = 1.6 \times 10^{-19} \text{ C} \times 1.0 \times 10^6 \frac{\text{m}}{\text{s}} \times 5 \text{ T} \sin 90 = 8 \times 10^{-13} \text{ N}$ for the velocity and the magnetic field perpendicular to each other. If the velocity vector were oriented at 45° then the magnetic force would be

$$F = qvB \sin \theta = 1.6 \times 10^{-19} \text{ C} \times 1.0 \times 10^6 \frac{\text{m}}{\text{s}} \times 5 \text{ T} \sin 45 = 5.7 \times 10^{-13} \text{ N}.$$

17.3. Since the magnetic force is given as $F_B = qvB$ and this net force produces the circular motion so we have that

$$F_B = qvB = \frac{mv^2}{R} \rightarrow v = \frac{qBR}{m} = \frac{1.6 \times 10^{-19} \text{ C} \times 6 \text{ T} \times 0.02 \text{ m}}{1.67 \times 10^{-27} \text{ kg}} = 1.15 \times 10^7 \frac{\text{m}}{\text{s}}.$$

17.4. From the velocity given, the component perpendicular to the field is

$v_{\perp} = v \sin \theta = 1 \times 10^5 \frac{\text{m}}{\text{s}} \sin 45 = 7.07 \times 10^4 \frac{\text{m}}{\text{s}}$ while the component parallel to the field is

$v_{\parallel} = v \cos \theta = 1 \times 10^5 \frac{\text{m}}{\text{s}} \cos 45 = 7.07 \times 10^4 \frac{\text{m}}{\text{s}}$. The perpendicular component will feel a

magnetic force and this force will cause the electron to trace out a circle with radius given by

$$F_B = F_C \rightarrow qv_{\perp}B = m \frac{v_{\perp}^2}{R} \rightarrow R = \frac{mv_{\perp}}{qB} = \frac{9.11 \times 10^{-31} \text{ kg} \times 7.07 \times 10^4 \frac{\text{m}}{\text{s}}}{1.6 \times 10^{-19} \text{ C} \times 2 \text{ T}} = 2.01 \times 10^{-7} \text{ m}.$$

Since the parallel component feels no force, this velocity is constant and merely carries the electron forward. The net motion is a helix about the magnetic field.

17.5. After acceleration through a potential difference of $\Delta V = 100 \text{ V}$, the electrons have gained a $KE = \frac{1}{2}mv^2 = e\Delta V$ by the work-kinetic energy theorem. Thus we can

find their velocity: $v = \sqrt{\frac{2e\Delta V}{m}} = \sqrt{\frac{2 \times 1.6 \times 10^{-19} \text{ C} \times 100 \text{ V}}{9.11 \times 10^{-31} \text{ kg}}} = 5.93 \times 10^6 \frac{\text{m}}{\text{s}}$. Then the

centripetal force is caused by the net magnetic force and we have

$$F_B = F_C \rightarrow qvB = m \frac{v^2}{R} \rightarrow B = \frac{mv}{qR} = \frac{9.11 \times 10^{-31} \text{ kg} \times 5.93 \times 10^6 \frac{\text{m}}{\text{s}}}{1.6 \times 10^{-19} \text{ C} \times 0.05 \text{ m}} = 6.7 \times 10^{-4} \text{ T}.$$

17.7. A charge-to-mass ratio experiment

a. After acceleration through a potential difference of $\Delta V = 200 \text{ V}$, the electrons have gained a $KE = \frac{1}{2}mv^2 = e\Delta V$ by the work-kinetic energy theorem. Thus we

can find their velocity: $v = \sqrt{\frac{2e\Delta V}{m}} = \sqrt{\frac{2 \times 1.6 \times 10^{-19} \text{ C} \times 200 \text{ V}}{9.11 \times 10^{-31} \text{ kg}}} = 8.4 \times 10^6 \frac{\text{m}}{\text{s}}$

b. The electrons orbit is a circle caused by the centripetal force and this is caused by the net magnetic force that acts on the electron. Equating the net magnetic force

to the centripetal force we can calculate the magnetic field. We have

$$F_B = F_C \rightarrow qvB = m \frac{v^2}{R}$$

$$\rightarrow B = \frac{mv}{qR} = \frac{9.11 \times 10^{-31} \text{ kg} \times 8.4 \times 10^6 \frac{\text{m}}{\text{s}}}{1.6 \times 10^{-19} \text{ C} \times 0.075 \text{ m}} = 6.4 \times 10^{-4} \text{ T} = 0.64 \text{ mT}$$

c. The angular velocity is given by $\omega = \frac{v}{R} = \frac{8.4 \times 10^6 \frac{\text{m}}{\text{s}}}{0.075 \text{ m}} = 1.1 \times 10^8 \text{ s}^{-1}$.

d. The frequency and period are given respectively as

$$\omega = 2\pi f \rightarrow f = \frac{\omega}{2\pi} = \frac{1.1 \times 10^8 \text{ s}^{-1}}{2\pi} = 1.8 \times 10^7 \text{ s}^{-1} \text{ and}$$

$$T = \frac{1}{f} = \frac{1}{1.8 \times 10^7 \text{ s}^{-1}} = 5.6 \times 10^{-8} \text{ s}.$$