Physics 111 Homework Solutions for Tuesday 1/27 and Wednesday 1/28

Tuesday, January 27, 2015

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 *3.0x10^-12^ N*, and this gives for a velocity in a *30 T* field, from

$$F = qvB \rightarrow v = \frac{F}{qB} = \frac{3.0\times10^{-12}\,N}{1.6\times10^{-19}\,C\times30T} = 6.25\times10^{5}\ \tfrac{m}{s}\,.$$

17.2. The magnetic force is given as

$F = qvB\sin\theta = 1.6\times10^{-19}\,C\times1.0\times10^{6}\ \tfrac{m}{s}\times5T\sin 90 = 8\times10^{-13}\,N$ for the velocity and the magnetic field perpendicular to each other. If the velocity vector were oriented at 45^{o} then the magnetic force would be

$$F = qvB\sin\theta = 1.6\times10^{-19}\,C\times1.0\times10^{6}\ \tfrac{m}{s}\times5T\sin 45 = 5.7\times10^{-13}\,N\,.$$

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

$$F_B = qvB = \frac{mv^2}{R} \rightarrow v = \frac{qBR}{m} = \frac{1.6\times10^{-19}C\times6T\times0.02m}{1.67\times10^{-27}kg} = 1.15\times10^7\,\tfrac{m}{s}.$$

17.4. From the velocity given, the component perpendicular to the field is $v_\perp = v\sin\theta = 1\times10^5\,\tfrac{m}{s}\sin45 = 7.07\times10^4\,\tfrac{m}{s}$ while the component parallel to the field is $v_{//} = v\cos\theta = 1\times10^5\,\tfrac{m}{s}\cos45 = 7.07\times10^4\,\tfrac{m}{s}$. The perpendicular component will feel a magnetic force and this force will cause the electron to trace out a circle with radius given by

$$F_B = F_C \rightarrow qv_\perp B = m\frac{v_\perp^2}{R} \rightarrow R = \frac{mv_\perp}{qB} = \frac{9.11\times10^{-31}kg\times7.07\times10^4\,\tfrac{m}{s}}{1.6\times10^{-19}C\times2T} = 2.01\times10^{-7}m.$$

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

17.5. After acceleration through a potential difference of *ΔV = 100* 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: $v = \sqrt{\frac{2e\Delta V}{m}} = \sqrt{\frac{2\times1.6\times10^{-19}C\times100V}{9.11\times10^{-31}kg}} = 5.93\times10^6\,\tfrac{m}{s}$. Then the centripetal force is caused by the net magnetic force and we have

$$F_B = F_C \rightarrow qvB = m\frac{v^2}{R} \rightarrow B = \frac{mv}{qR} = \frac{9.11\times10^{-31}kg\times5.93\times10^6\,\tfrac{m}{s}}{1.6\times10^{-19}C\times0.05m} = 6.7\times10^{-4}T.$$

17.6. The radius of the electron's orbit is determined by the magnetic force. We have

$$F_B = F_C \rightarrow qv_\perp B = m\frac{v_\perp^2}{R}$$

$$\rightarrow R = \frac{mv_\perp}{qB} = \frac{9.11\times10^{-31}kg\times0.05\times3\times10^8\,\tfrac{m}{s}\sin45}{1.6\times10^{-19}C\times0.5T} = 1.21\times10^{-4}m$$

The pitch is given as product of the parallel component of the velocity (a constant) and the period of the circular motion about the magnetic field line. The period is given by $T = \frac{2\pi R}{v_\perp} = \frac{2\pi\times1.21\times10^{-4}m}{0.05\times3\times10^8\,\tfrac{m}{s}\sin45} = 7.15\times10^{-11}s$ and thus the pitch is

$$p = v\cos\theta\times T = 0.05\times3\times10^8\,\tfrac{m}{s}\cos45\times7.15\times10^{-11}s = 7.6\times10^{-4}m.$$

17.7. A charge-to-mass ratio experiment

a. After acceleration through a potential difference of *ΔV = 200* 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: $v = \sqrt{\frac{2e\Delta V}{m}} = \sqrt{\frac{2\times1.6\times10^{-19}C\times200V}{9.11\times10^{-31}kg}} = 8.4\times10^6\,\tfrac{m}{s}$

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

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

$$\rightarrow B = \frac{mv}{qR} = \frac{9.11\times10^{-31}\,kg\times8.4\times10^6\,\frac{m}{s}}{1.6\times10^{-19}\,C\times0.075m} = 6.4\times10^{-4}\,T = 0.64mT$$

c. The angular velocity is given by $\omega = \frac{v}{R} = \frac{8.4\times10^6\,\frac{m}{s}}{0.075m} = 1.1\times10^8\,s^{-1}$.

d. The frequency and period are given respectively as

$$\omega = 2\pi f \rightarrow f = \frac{\omega}{2\pi} = \frac{1.1\times10^8\,s^{-1}}{2\pi} = 1.8\times10^7\,s^{-1}$$ and

$$T = \frac{1}{f} = \frac{1}{1.8\times10^7\,s^{-1}} = 5.6\times10^{-8}\,s.$$

17.8 For ^{64}Zn, the mass is 64 times $1.67x10^{-27}\ kg = 1.0688x10^{-25}\ kg$, while for ^{66}Zn, the mass is 66 times $1.67x10^{-27}\ kg = 1.1022x10^{-25}\ kg$. The magnetic force causes the particles to move in a circle of radius r at constant speed given by

$$r = \frac{mv}{qB} = \frac{m}{qB}\sqrt{\frac{2q\Delta V}{m}} = \frac{1}{B}\sqrt{\frac{2m\Delta V}{q}}.$$

For ^{64} Zn, the radius is

$$r = \frac{1}{B}\sqrt{\frac{2m\Delta V}{q}} = \frac{1}{10T}\sqrt{\frac{2\times1.0688\times10^{-25}\,kg\times10000V}{2\times1.6\times10^{-19}\,C}} = 8.2mm.$$

For ^{66}Zn, the radius is $r = \frac{1}{B}\sqrt{\frac{2m\Delta V}{q}} = \frac{1}{10T}\sqrt{\frac{2\times1.1022\times10^{-25}\,kg\times10000V}{2\times1.6\times10^{-19}\,C}} = 8.3mm.$

Wednesday, January 28, 2015

Chapter 15

Questions

- None

Multiple-Choice

- None

Problems

- None