Physics 111 Homework Solutions for Wednesday 10/1 and Thursday 10/2

Wednesday, October 1, 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 $3.0x10^{-12}$ *N*, and this gives for a velocity in a *30 T* field, from

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

17.2. The magnetic force is given as

$F = qvB\sin\theta = 1.6\times10^{-19}\,C\times1.0\times10^{6}\,\tfrac{m}{s}\times5T\sin90 = 8\times10^{-13}\,N$ 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

$$F = qvB\sin\theta = 1.6\times10^{-19}\,C\times1.0\times10^{6}\,\tfrac{m}{s}\times5T\sin45 = 5.7\times10^{-13}\,N.$$

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 $v_\perp = v\sin\theta = 1\times10^5 \tfrac{m}{s}\sin 45 = 7.07\times10^4 \tfrac{m}{s}$ while the component parallel to the field is $v_{//} = v\cos\theta = 1\times10^5 \tfrac{m}{s}\cos 45 = 7.07\times10^4 \tfrac{m}{s}$. 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

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

17.7. 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

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

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

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

d. The frequency and period are given respectively as

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

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

Thursday, October 2, 2014

Chapter 15

Questions

- None

Multiple-Choice

- None

Problems

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

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

$$\rightarrow R = \frac{mv_\perp}{qB} = \frac{9.11\times10^{-31} kg\times0.05\times3\times10^{8} \frac{m}{s}\sin 45}{1.6\times10^{-19} C\times0.5T} = 1.21\times10^{-4} m$$

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 $T = \frac{2\pi R}{v_\perp} = \frac{2\pi\times1.21\times10^{-4} m}{0.05\times3\times10^{8} \frac{m}{s}\sin 45} = 7.15\times10^{-11} s$ and thus the pitch is

$$p = v\cos\theta\times T = 0.05\times3\times10^{8} \tfrac{m}{s}\cos 45\times7.15\times10^{-11} s = 7.6\times10^{-4} m.$$

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

17.10 From a free body diagram we find for the forces in the vertical direction $F_B - ky - ky = 0 \rightarrow F_B = 2kx$. The magnetic force is given as *ILB* and this produces for the stretch $x = \frac{ILB}{2k} = \frac{2.5A \times 0.5m \times 2T}{2 \times 10 \frac{N}{m}} = 0.125m = 12.5cm$

17.11. The torque is given by $\tau = IAB \sin\theta$. The cross sectional area of the loop is $A = \pi r^2 = \pi(0.025m)^2 = 1.96 \times 10^{-3} m^2$. The minimum torque (which equals *0 Nm*)is then the magnetic moment is parallel to the magnetic field and the maximum torque is when the magnetic moment is perpendicular to the magnetic field. The maximum torque is $\tau = IAB \sin\theta = 2A \times 1.96 \times 10^{-3} m^2 \times 0.5T \times \sin 90 = 1.96 \times 10^{-3} Nm$

17.21 A cyclotron

a. To calculate the radii of a particle of mass *m* and charge *q*, we equate the magnetic force to the centripetal force experienced by the mass. This gives for the radius of a particle of mass $m, F_B = F_C \rightarrow qvB = \frac{mv^2}{r} \rightarrow r = \frac{mv}{qB}$.

b. We want the particle to travel a semi-circle of distance πr and calculate the amount of time that this takes. To do this we need to know that velocity of the particle. Again we equate the centripetal force experienced by the particle to the magnetic force and this time solve for the velocity. Doing this we find $F_B = F_C \rightarrow qvB = \frac{mv^2}{r} \rightarrow v = \frac{qrB}{m}$. The velocity, a constant, is the ratio of the distance traveled by the time it takes to travel this distance. Thus the time is $v = \frac{\pi r}{t} \rightarrow t = \frac{\pi r}{v} = \frac{\pi r m}{qrB} = \frac{\pi m}{qB}$.