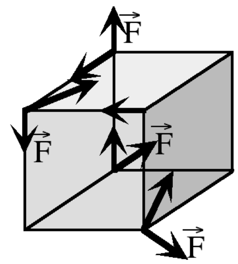
Q12 $q > 0$, so $\vec{F}$ is in the direction of $\vec{v} \times \vec{B}$




(a) $\vec{v} \times \vec{B}$ is $-\hat{k}$. $|F| = q\,v\,B \sin\theta = qvB$. $\vec{F} = -\,qvB\,\hat{k}$

(b) $\vec{v} \times \vec{B}$ is $+\hat{j}$. $|F| = q\,v\,B \sin\theta = qvB$. $\vec{F} = qvB\,\hat{j}$ (c) $\vec{v} \times \vec{B}$ is 0.

(d) $\vec{v} \times \vec{B}$ is $-\hat{j}$. $|F| = q\,v\,B \sin\theta = qvB \sin 45°$. $\vec{F} = -\,qvB/\sqrt{2}\;\hat{j}$

(e) $\vec{v} \times \vec{B}$ is at 45° between the $-\hat{k}$ and $-\hat{j}$ direction. $|F| = q\,v\,B \sin 90° = qvB$.

$\vec{F} = qvB\,(-1/\sqrt{2}\,\hat{j} - 1/\sqrt{2}\,\hat{k})$

The above method uses RHR for direction and $AB \sin\theta$ for the magnitude of $\vec{A}\times\vec{B}$. You can use component form, where $\vec{B} = B\,\hat{i}$ and $\vec{v}$ is (a) $v\,\hat{j}$, (b) $v\,\hat{k}$, (c) $-v\,\hat{i}$, (d) $+v/\sqrt{2}\,\hat{i} - v/\sqrt{2}\,\hat{k}$, and (e) $+v/\sqrt{2}\,\hat{j} - v/\sqrt{2}\,\hat{k}$, and get exactly the same results.

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46 (a) $\vec{\tau} = \vec{\mu} \times \vec{B} = NIA\,(+\hat{k}) \times B\,(+\hat{j}) = NIAB\,(-\hat{i})$, rotates about x. $U = -\,\vec{\mu}\cdot\vec{B} = -\,NIAB\,(+\hat{k})\cdot(+\hat{j}) = 0$

(b) $\vec{\mu} \times \vec{B} = NIA\,(+\hat{j}) \times B\,(+\hat{j}) = 0$, aligned with $\vec{B}$. $-\,\vec{\mu}\cdot\vec{B} = -\,NIAB\,(+\hat{j})\cdot(+\hat{j}) = -NIAB$, low energy.

(c) $\vec{\mu} \times \vec{B} = NIA\,(-\hat{k}) \times B\,(+\hat{j}) = NIAB\,(+\hat{i})$, rotates about x. $-\,\vec{\mu}\cdot\vec{B} = -\,NIAB\,(-\hat{k})\cdot(+\hat{j}) = 0$

(d) $\vec{\mu} \times \vec{B} = NIA\,(-\hat{j}) \times B\,(+\hat{j}) = 0$, opposite $\vec{B}$. $-\,\vec{\mu}\cdot\vec{B} = -\,NIAB\,(-\hat{j})\cdot(+\hat{j}) = +NIAB$, high energy.

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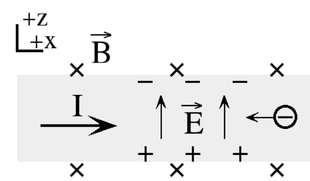
51 $J = nqv_d \rightarrow \dfrac{120\text{A}}{(11.8\times10^{-3}\text{m})(0.23\times10^{-3}\text{m})} = (5.85\times10^{28}\text{m}^{-3})(1.6\times10^{-19}\text{C})\,v_d$




$\Rightarrow v_d = 4.7\times10^{-3}$m/s. (b) Silver is an ordinary conductor, where the charge carriers are negative, so current in the $+\hat{i}$ is really negative charge flow in the $-\hat{i}$. These charges experience $\vec{F}_B = q\,\vec{v} \times \vec{B}$ in the $+\hat{k}$ direction ($\vec{v} \times \vec{B}$ is $-\hat{k}$, but $q < 0$), causing them to pile up on the top surface, creating an electric field upward (toward them), $+\hat{k}$ direction.

$qE = qv_dB \;\Rightarrow v_d = \dfrac{E}{B}$. $(4.7\times10^{-3}\text{m/s}) = \dfrac{E}{0.95\text{T}} \Rightarrow E = 4.5\times10^{-3}$N/C. (c) $(4.5\times10^{-3}\text{V/m})(0.0118\text{m}) = 53\mu\text{V}$

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57 $R = \dfrac{mv}{qB} \Rightarrow mv = qRB \Rightarrow \tfrac{1}{2}mv^2 = \dfrac{(mv)^2}{2m} = \dfrac{q^2R^2B^2}{2m}$. (a) At $R_{max}$, $\tfrac{1}{2}mv^2 = \dfrac{(1.6\times10^{-19}\text{C})^2(0.4\text{m})^2(0.85\text{T})^2}{2(1.67\times10^{-27}\text{kg})}$ $= 8.86\times10^{-13}\text{J} = 5.54$MeV. (b) Now why do they say "at this maximum radius"?! For they have already made a big deal out of the fact that the frequency is *independent* of the radius. Oh, well. $f = \omega/2\pi = \dfrac{qB}{m}\dfrac{1}{2\pi} \Rightarrow$

$T = \dfrac{1}{f} = \dfrac{2\pi m}{qB} = \dfrac{2\pi(1.67\times10^{-27}\text{kg})}{(1.6\times10^{-19}\text{C})(0.85\text{T})} = 7.7\times10^{-8}$s. (c) Since $KE \propto B^2$, B would only have to go up by $\sqrt{2}$, $0.85\text{T}\sqrt{2} = 1.2$T. (d) q is twice is large, and $KE \propto q^2$, which would double the KE, but $KE \propto 1/m$, and the mass is four times as large, so they cancel. Same $KE_{max}$.

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61 $\vec{F} = q\,\vec{v} \times \vec{B} = q(1.05\times10^6\text{m/s})(-3\hat{i}+4\hat{j}+12\hat{k})\times(-\hat{k})(0.12\text{T}) = q(1.05\times10^6\text{m/s})\big(3(-\hat{j}) + 4(-\hat{i})\big)(0.12\text{T}) = -$ $q\big(5.04\times10^5\text{N/C}\;\hat{i} + 3.78\times10^5\text{N/C}\;\hat{j}\big)$. Equating magnitudes, $1.25 = |q|\sqrt{(5.04\times10^5\text{N/C})^2+(3.78\times10^5\text{N/C})^2}$ $\Rightarrow |q| = 1.98\times10^{-6}$C. (b) $\vec{F} = -\,(-1.98\times10^{-6}\text{C})\big(5.04\times10^5\text{N/C}\;\hat{i} + 3.78\times10^5\text{N/C}\;\hat{j}\big) = 1.0\text{N/C}\;\hat{i} + 0.75\text{N/C}\;\hat{j}$. $\vec{a}$ $= \vec{F}/m = 3.88\times10^{14}\text{m/s}^2\;\hat{i} + 2.91\times10^{14}\text{m/s}^2\;\hat{j}$.

(c)The force is $\perp$ to $\vec{B}$, which is along the z–axis, so the force is in the x–y plane. Accordingly, it cannot alter the z–component of velocity. Thus, the particle will continue with a constant $v_z$, while its motion in the x–y direction is circular. $R = \dfrac{mv}{qB}$, but the v here is the speed in the x–y plane, independent of its z–motion.

$v = \sqrt{v_x^2+v_y^2} = 1.05\times10^6\text{m/s}\,\sqrt{3^2+4^2} = 5.25\times10^6$m/s. Thus, $R = \dfrac{(2.58\times10^{-15}\text{kg})(5.25\times10^6\text{m/s})}{(1.98\times10^{-6}\text{C})(0.12\text{T})} = 0.057$m

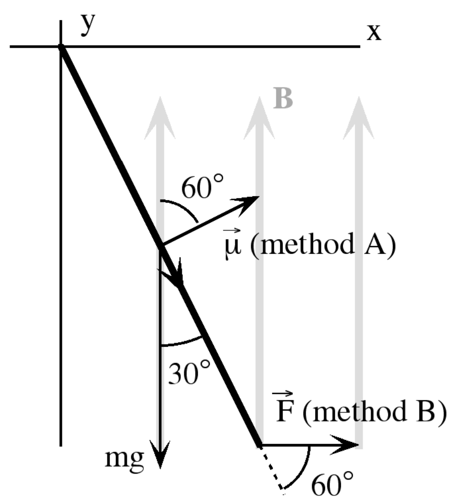
(d) $f = \omega/2\pi = \dfrac{qB}{2\pi m} = \dfrac{(1.98\times10^{-6}\text{C})(0.12\text{T})}{2\pi(2.58\times10^{-15}\text{kg})} = 1.47\times10^7$Hz.

(e) It will have made two complete circles in the x–y direction, so (x,y) = (R,0). It moves at constant $v_z$ of $(1.05\times10^6\text{m/s}\cdot12)$. $T = 1/f = 6.81\times10^{-8}$s. Thus, $z = (1.05\times10^6\text{m/s}\cdot12)(2\cdot6.81\times10^{-8}\text{s}) = 1.72$m

65 Do read the discussion of a "velocity selector", a clever device. $v = \frac{E}{B} = \frac{1.88\times10^4\text{N/C}}{0.701\text{T}} = 2.68\times10^4\text{m/s}$.

Once outside the velocity selector, $qvB = m\frac{v^2}{r}$ applies, so r = mv/qB. Different m ⇒ different r. After half a circle, each will be one diameter from where it started. D = 2mv/qB. Thus, ΔD = (2v/qB) Δm = $\frac{2(2.68\times10^4\text{m/s})}{(1.6\times10^{-19}\text{C})(0.701\text{T})}\,2\times1.66\times10^{-27}\text{kg} = 1.6\times10^{-3}\text{m}$.

75 It's a dipole, and the net magnetic force on it is zero. Gravity is down, so there must be an upward force at the "hinge" *ab*, or it would fall. Thus, it's not ΣF = 0, but Στ = 0. $\tau_{mg}$ (clockwise) = r F sin θ = (0.04m)[(28cm×1.5×$10^{-4}$kg/cm)(9.8m/s$^2$)] sin30° = 8.23×$10^{-4}$N·m.
For the magnetic torque there are two methods.




Method A:
$\vec{\mu}$ is to right and up by RHR. For its tendency to align with $\vec{B}$ to be counterclockwise (opposite $\tau_{mg}$), $\vec{B}$ has to be in the *plus* y direction.
$\tau_B$ = μ B sin θ = (IA) B sin θ = (8.2A)(48×$10^{-4}$m$^2$) B sin 60°
Method B:
The forces on the segments "hanging down" from *ab* are parallel to the z–axis, so produce no torque about that axis. For the force on the bottom segment to be to right (opposing $\tau_{mg}$), $\vec{B}$ has to be in +y. $\tau_B$ = r F sin θ = (0.08m) | I $\vec{\ell}\times\vec{B}$ | sin 60°= (0.08m)(8.2A)(0.06m) sin 60°
Both give same equation: $\tau_{mg} = \tau_B$ → 8.23×$10^{-4}$N·m = (8.2A)(48×$10^{-4}$m$^2$) B sin 60° ⇒ B = 0.0242T