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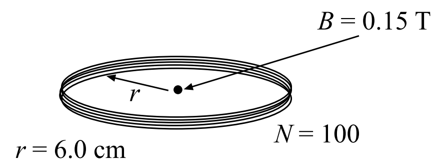
Mar. 26, 2008

# Quiz #4 — Spring 2008

## Phys 2020

**1.** Suppose we have a circular wire coil of radius 6.00 cm, with 100 turns of wire. We want to create a magnetic field in the center of the coil of magnitude 0.15 T. What current do we need?

(Hint: For a coil with $N$ turns, the $B$ field in the center is $N$ times the field you get from a loop with one turn.)




Use

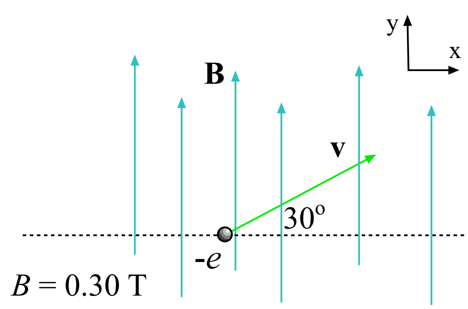
$$B_{\text{coil}} = N\frac{\mu_0 I}{2R} \qquad \Longrightarrow \qquad I = \frac{B_{\text{coil}}(2R)}{\mu_0 N}$$

Plug in numbers:

$$I = \frac{(0.15)2(0.0600)}{(4\pi \times 10^{-7})(100)} = 143\ \text{A}$$

**2.** In a uniform magnetic field of magnitude 0.30 T, pointing in the $+y$ direction, an electron moves with speed $4.0 \times 10^6\,\frac{\text{m}}{\text{s}}$ in the $xy$ plane, in a direction $+30°$ from the $x$ axis, as shown at the right.

Find the magnitude and direction of the force on the electron.

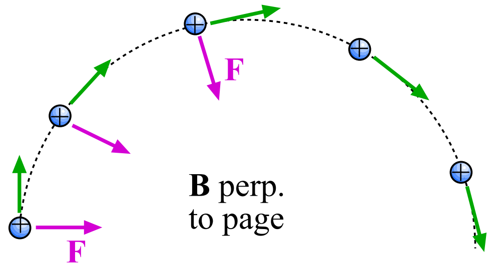



The angle between the velocity and magnetic field vectors is $60°$, so the magnitude of the force is

$$F = |qvB\sin\alpha| = (1.60 \times 10^{-19}\ \text{C})(4.0 \times 10^6\,\tfrac{\text{m}}{\text{s}})(0.30\ \text{T})\sin 60° = 1.66 \times 10^{-13}\ \text{N}$$

If the charge were positive then the right hand rule (thumb=velocity, fingers=field palm=force) would say that the force goes out of the page. But an electron has a negative charge, so the force goes $\boxed{\text{into the page}}$.

**3.** A particle with speed $2.5 \times 10^5 \frac{\text{m}}{\text{s}}$, charge $+e$ and mass $1.00 \times 10^{-26}$ kg moves perpendicularly to a uniform magnetic field of magnitude and as a result has a circular orbit, as shown to the right. The radius of the circle is 12.0 cm. The $B$ field is perpendicular to the page.




**a)** If the particle goes in the direction shown, should the $B$ field go into the page or out of the page? You must *explain* how you *reasoned out* your choice.

The (net) force on the particle points toward the center of the circle; I have added force vectors to the original figure. This force is the magnetic force on the particle. Applying the right-hand rule (thumb=velocity, fingers=field, palm=force; note, charge is *positive*) we will get the force in the proper direction if the magnetic field points out of the page.

**b)** What is the magnitude of the $B$ field?

The formula derived for circular motion in a $B$ field gave $r = \frac{mv}{qB}$. This gives

$$B = \frac{mv}{qr}$$

Plug in the numbers:

$$B = \frac{(1.00 \times 10^{-26} \text{ kg})(2.5 \times 10^5 \frac{\text{m}}{\text{s}})}{(1.60 \times 10^{-19} \text{ C})(0.120 \text{ m})} = 0.130 \text{ T}$$

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**You must show all your work and include the right units with your answers!**

$$e = 1.60 \times 10^{-19} \text{ C} \qquad K = 8.99 \times 10^9 \frac{\text{N}\cdot\text{m}^2}{\text{C}^2} \qquad \epsilon_0 = 8.854 \times 10^{-12} \frac{\text{C}^2}{\text{N}\cdot\text{m}^2} \qquad \mu_0 = 4\pi \times 10^{-7} \frac{\text{N}}{\text{A}^2}$$

$$I = \frac{Q}{\Delta t} \qquad V = IR \qquad P = VI = I^2R \qquad R_{\text{ser}} = R_1 + R_2 + \cdots \qquad \frac{1}{R_{\text{par}}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$$

$$B_{\text{wire}} = \frac{\mu_0 I}{2\pi r} \qquad B_{\text{loop}} = \frac{\mu_0 I}{2R} \qquad B_{\text{coil}} = N\frac{\mu_0 I}{2R} \qquad B_{\text{sol}} = \mu_0 I \frac{N}{L}$$

$$F = |qvB\sin\theta| \qquad F = ILB\sin\theta \qquad r = \frac{mv}{qB} \qquad m = \left(\frac{qr^2}{2V}\right)B^2 \qquad \frac{F}{L} = \frac{\mu_0 I_1 I_2}{2\pi d}$$