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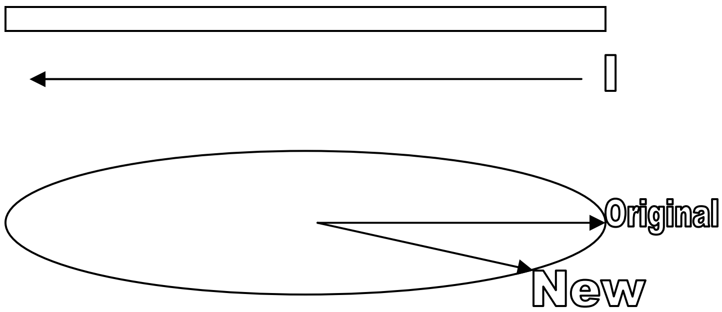
Physics 2 Notes – March 7, 2006

17.6) a)



b)

$$Arc\tan\left[\frac{B_{Applied}}{B_{Earth}}\right] = \frac{\pi}{18} = 10^{\circ} \qquad \frac{B_{Applied}}{B_{Earth}} = Tan\left[\frac{\pi}{18}\right]$$

$$B_{Applied} = \frac{\mu_0}{4\pi}\frac{2I}{r} \qquad I = \frac{4\pi r}{2\mu_0}Tan\left[\frac{\pi}{18}\right]B_{Earth}$$

$$10^7\,\frac{A}{T\cdot m}\cdot 0.005m\cdot Tan\left[\frac{\pi}{18}\right]\cdot 2\times 10^{-5}T = 0.176A$$

17.7) Clearly, one can take the equation on page 665 for I, then substitute it in as $B_{Applied}$ in my formula from the previous problem, being sure to align the loop such that its field will be perpendicular to the Earth's. Then, this formula can be solved for I.

17.8) By superposition, I take the magnetic field from the loop

$$B_{loop} = \frac{\mu_0}{4\pi}\frac{2\pi R^2 I}{\left(z^2+R^2\right)^{\frac{3}{2}}} \qquad z\to 0 \qquad \frac{\mu_0}{4\pi}\frac{2\pi R^2 I}{\left(R^2\right)^{\frac{3}{2}}} = \frac{\mu_0}{4\pi}\frac{2\pi I}{R}$$

$$B_{long\quad wire} = \frac{\mu_0}{4\pi}\frac{2I}{R}$$

$$B_{loop} + B_{long\quad wire} = \frac{\mu_0}{4\pi}\frac{2(1+\pi)I}{R}$$

This field points in the direction indicated by the right hand rule from the long wire, which will be along the axis of the page.

Suppose we repeated problem 17.6, where my magnetic field applied pointed at some non-perpendicular angle α to the Earth's field. Could I still find the current's magnitude? Sure. Define the Earth's field to be along the positive x-axis, e.g. zero.

$$Arc\tan\left[\frac{B_{Applied}\sin\alpha}{B_{Earth}+B_{Applied}\cos\alpha}\right]=\theta_{Displacement} \qquad \frac{B_{Applied}\sin\alpha}{B_{Earth}+B_{Applied}\cos\alpha}=Tan[\theta_{Displacement}]$$

$$B_{Applied}\sin\alpha = Tan[\theta_{Displacement}](B_{Earth}+B_{Applied}\cos\alpha)$$

$$B_{Applied}\sin\alpha - Tan[\theta_{Displacement}]B_{Applied}\cos\alpha = Tan[\theta_{Displacement}]B_{Earth}$$

$$B_{Applied}(\sin\alpha - Tan[\theta_{Displacement}]\cos\alpha) = Tan[\theta_{Displacement}]B_{Earth}$$

$$B_{Applied} = \frac{Tan[\theta_{Displacement}]B_{Earth}}{(\sin\alpha - Tan[\theta_{Displacement}]\cos\alpha)}$$

At this point, I would substitute the formula for magnetic field from my wire, coil, or whatever is creating this displacement. Beware! I can gain no information from my compass on a field with no component in the direction perpendicular to my reference field (Earth's field). In this case, my tangent will be zero and alpha will be zero, so that I end up with division by zero in my result.