Homework Solutions

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Let right be the x-direction and up be the y-direction, and out of the paper be z. Then $\mathbf{B} = B\,\mathbf{k}$, and a current to the left through the bar has $\mathbf{t} = -\mathbf{i}$, and causes the bar to experience force

$$\mathbf{F} = I\mathbf{t}\ell \times \mathbf{B} = I\ell B(-\mathbf{i} \times \mathbf{k}) = I\ell B\mathbf{j}$$

With gravity exerting $\mathbf{F}_G = -Mg\mathbf{j}$ we have equilibrium if

$$0 = I\ell B\mathbf{j} - Mg\mathbf{j}, \qquad I = \frac{Mg}{\ell B}$$

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If the setup is horizontal, there is no gravity, and with the axes oriented as in the previous problem;

$$\mathbf{F} = M\mathbf{a} = M\frac{dv}{dt}(-\mathbf{j}) = I\mathbf{t}\ell \times \mathbf{B} = I\ell B(\mathbf{i} \times \mathbf{k}) = -I\ell B\mathbf{j}$$

and so

$$v(t) = \frac{I\ell B}{M}\,t$$

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Using example **84** we have $d\ell\mathbf{t} \times (-\mathbf{r}) = r^2(\theta)\,d\theta\mathbf{k}$, and so

$$\mathbf{B}(0) = \frac{\mu_0}{4\pi}\int_{\frac{\pi}{2}}^{\frac{5\pi}{2}} \frac{I\theta^4\,d\theta\mathbf{k}}{\theta^6} = \frac{\mu_0 I}{4\pi}\frac{8}{5\pi}\mathbf{k}$$

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$$|\mathbf{B}(0)| = \frac{1}{2}\Big(\frac{\mu_0 I}{2a} + \frac{\mu_0 I}{2b}\Big) \quad \text{out}$$

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$$|\mathbf{B}(0)| = \frac{1}{2}\Big(\frac{\mu_0 I}{2b} - \frac{\mu_0 I}{2a}\Big) \quad \text{in}$$

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$$|\mathbf{B}(0)| = 2\cdot\frac{1}{2}\Big(\frac{\mu_0 I}{2\pi a}\Big) + \frac{1}{4}\Big(\frac{\mu_0 I}{2a}\Big) \quad \text{in}$$

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$$|\mathbf{B}(0)| = \frac{1}{2}\Big(\frac{\mu_0 I}{2\pi a}\Big) \quad \text{out}$$

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$$|\mathbf{B}(0)| = \frac{\Theta}{2\pi}\Big(\frac{\mu_0 I}{2a} - \frac{\mu_0 I}{2b}\Big) \quad \text{out}$$