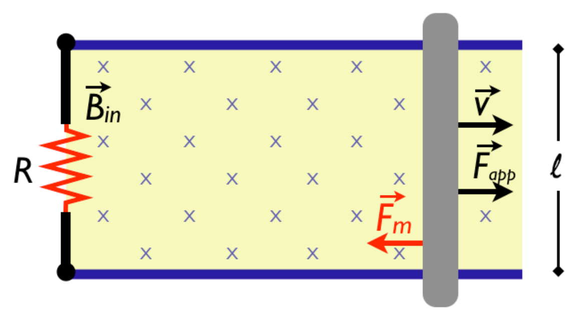
Quiz 7: Solution

1. During an in-class demonstration, we dropped a magnet and a non-magnet of equal weight and size through a copper tube. The non-magnet fell through the tube at the expected rate, but the magnet took many times longer to fall out, due to eddy current braking. Is it possible to have a magnet strong enough (or a tube conductive enough, *etc*) that it would actually *stop* inside the tube? Explain.

No.[i] The eddy current braking comes from induced currents in the copper tube due to the falling magnet. The falling magnet represents a time-varying B field, which creates a time-varying flux through the copper tube. If the magnet actually stopped, there would be no eddy currents at all, and nothing to hold the magnet against gravity. Once the magnet stops, the very force slowing it down ceases to exist. The flux in the tube is changing only because the magnet has some non-zero velocity. No emf, and therefore no eddy currents result from a stationary magnet giving a constant flux through the tube.

Putting it another way: the force is due to the relative velocity of the magnet and the charges in the copper. The magnetic force is $F = qvB$, where v is the *relative* velocity o f the tube and magnet. If $v = 0$, there is no force - so if the magnet could actually be stopped, the force holding it up would go to zero, and it would fall again! Clearly, the answer is no.

2. A conducting rod of length l moves on two (frictionless) horizontal rails, as shown to the right. A constant force of magnitude $|\vec{\mathbf{F}}_{\text{app}}| = 1.0\,\text{N}$ moves the bar at a uniform speed of $|\vec{\mathbf{v}}| = 2.0\,\text{m/s}$ through a magnetic field $\vec{\mathbf{B}}$ directed into the page. The resistor has a value $R = 8.0\,\Omega$.



What is the current through the resistor R?

Simple solution: the mechanical power supplied must exactly balance the electrical power dissipated – conservation of energy. If the bar is moving at a velocity v under the influence of a constant external force F, the power is just Fv since F and v are in the same direction. The resistive power dissipated is I^2R. Equating, and solving for I:

$$\mathscr{P}_{in} = \mathscr{P}_{out} \qquad \Longrightarrow \qquad Fv = I^2R \qquad \Longrightarrow \qquad I = \sqrt{\frac{Fv}{R}} = \frac{1}{2}\,\text{A}$$

[i] One could make arguments about supercondutors and the Meissner effect, but that is very different physics than we are worrying about here.