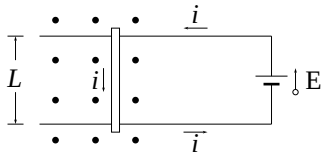
Primitive motor revisited



There are two sources of emf in this circuit. The battery emf $\mathcal{E}$ pushes current in the direction shown which, as we saw last week, moves the slide wire to the left. Once the slide wire moves, however, Φ_B increases and, by Faraday's law, an induced emf springs into existence to *oppose* the change in Φ_B. By Lenz's law this emf acts to send current opposite to the direction shown. This decreases the current, and hence the magnetic force, until the current drops to zero, the magnetic force vanishes, and the wire moves with a constant velocity v_t ("terminal velocity"). This is the velocity at which the induced emf exactly balances the battery emf, i.e. when

$$\mathcal{E} = \frac{d\Phi_B}{dt}.$$

But

$$\frac{d\Phi_B}{dt} = BvL,$$

so

$$v_t = \frac{\mathcal{E}}{BL}.$$

Grading: 2 points for any sort of start up
(e.g. figure, stating "Faraday's law" or "Lenz's law")
2 points for motion to left
2 points for current drops to zero
4 points for formula $\mathcal{E}/BL$