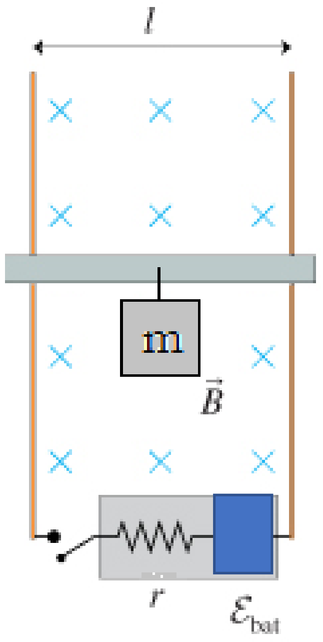
D.2 Motors



Say you want to lower a weight m = 50kg at 2.5m/s. So you connect a circuit, where ξ_{bat} = ?, and its internal resistance is r = 200mΩ, and ℓ = 1.6m and you immerse the circuit in a magnetic field B = 2T.
What should ξ_{bat} be? And which way should it point?

First, the current must be pointed right along the bar to generate an upward $\mathbf{F}_B = \ell \mathbf{I} \times \mathbf{B}$.
And this necessitates the battery to oriented + -.

Now let's see what current we need. So necessary force is:

$$F = mg$$

$$mg = lIB\sin\theta$$

$$mg = lIB\sin 90^\circ$$

$$I = \frac{mg}{lB} = \frac{(50\,\text{kg})(9.8\,\text{m/s}^2)}{(1.6\,\text{m})(2\,\text{T})} = 153\,\text{A}$$

Then let's see what ξ_{bat} must be, using KVL…

$$\xi_{batt} - Ir + \xi_{effective} = 0$$

$$\xi_{batt} = Ir - \xi_{eff.}$$

$$\xi_{batt} = Ir - Blv\cos\varphi$$

$$\xi_{batt} = (153\,\text{A})(200\times10^{-3}\,\Omega) - (2\,\text{T})(1.6\,\text{m})(2.5\,\text{m/s})\cos 0^\circ$$

$$\xi_{batt} = 22.6\,\text{V}$$

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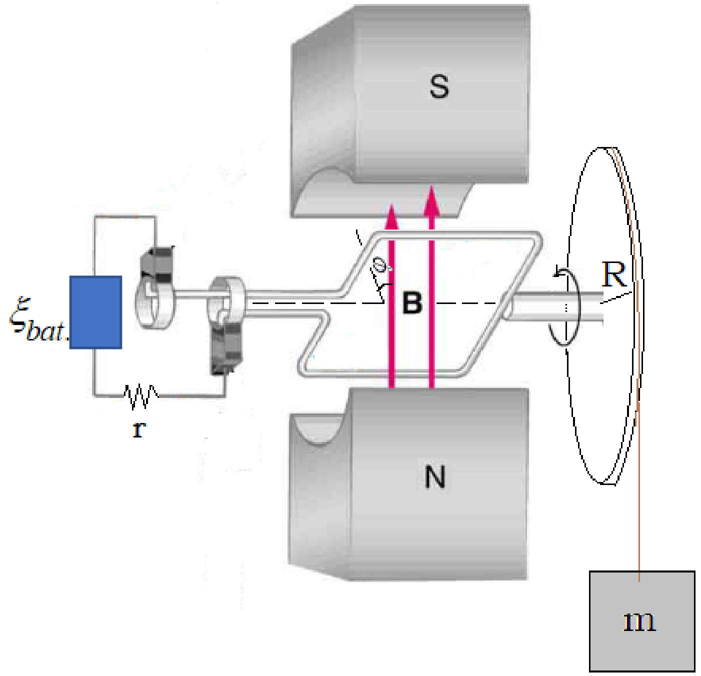

We got a battery w/ potential difference ξ_{bat} = ?, and internal resistance r = 50mΩ.
Connected to same 100 turn, 10cm×10cm loop.
And immersed in same B = 2T field.

Say we want to be able to raise a 20kg weight, about axle R = 5cm, at 2 rev/second.
What should ξ_{bat} be at least?

First let's see what current we need. So necessary torque is:

$$\tau = \mu B \sin\varphi$$

$$Rmg = (NIA)B\sin\varphi$$

$$Rmg < (NIA)B\sin 90^\circ$$

$$I > \frac{Rmg}{NAB}$$

$$> \frac{(0.05\text{m})(20\,\text{kg})(9.8\text{m/s}^2)}{(100)(0.10^2\,\text{m}^2)(2\text{T})}$$

$$I > 4.9\text{A}$$

Then let's see how ξ_{bat} relates to this. Apply KVL to the loop…

$$\xi_{batt} - ir - \xi_{effective} = 0$$

$$\xi_{batt} = NBA\omega\sin\varphi + Ir$$

$$\xi_{batt} > NBA\omega + (4.9\text{A})r$$

$$\xi_{batt} > (100)(2\text{T})(0.10^2\,\text{m}^2)(2\pi\cdot 2\text{Hz}) + (4.9\text{A})(50\times10^{-3}\Omega)$$

$$\xi_{batt} > 25\text{V}$$