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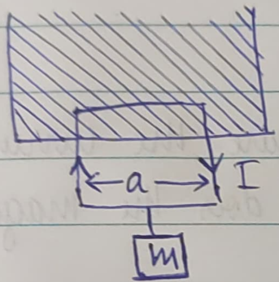
20221263 BATCH-6

Q A rectangular loop of wire, supporting a mass m, hangs vertically with one end in a uniform magnetic ~~loop~~ field B, which points into the page in the shaded region shown in the figure. For what current I, in the loop would the magnetic ~~field~~ force upward exactly balance the gravitational force downward?



Sol^n. Formula known $F = q\, v \times B$

for ~~small~~ charge distribution

$$F = \int (v \times B)\, dq$$

$$dq = \lambda\, dl$$

$$F = \int (\vec{v} \times \vec{B})\, \lambda\, dl$$

Since $I = \frac{q}{t}$ $\quad v \times \lambda = \frac{l}{t} \times \frac{q}{l} = \frac{q}{t} = I$

$$= \int (\vec{I} \times \vec{B})\, dl$$

If dl pts in the same direction as $\vec{I}$

$$F = \int I\, (\vec{dl} \times \vec{B})$$

I is constant

$$\therefore \quad F = I \int \vec{dl} \times \vec{B}$$

→ The current should be in clock wise direction such that the magnetic force is upwards and

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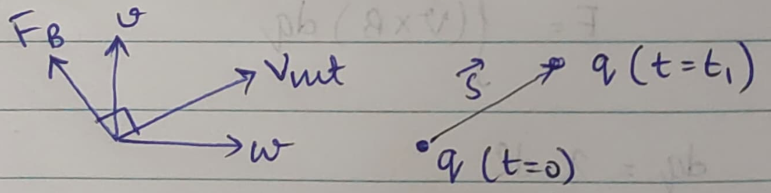
balances the weight

$$F = I \int dl \times B \sin 90$$
$$= IB \int dl$$
$$= IBa$$
$$F = IBa = mg$$
$$\therefore I = \frac{mg}{Ba}$$

What happens when you increase the current?
The loop moves upward, but does the magnetic force do work? NO!
Because when the loop moves up, the net velocity on a single charge changes.



the force now has become tilted and is $\perp$ to the displacement. And hence no work is done
But then where does the energy come from?
The net force F_B has a horizontal component which opposes the current. And hence the work is done by battery / source which does work to maintain the current in the loop.