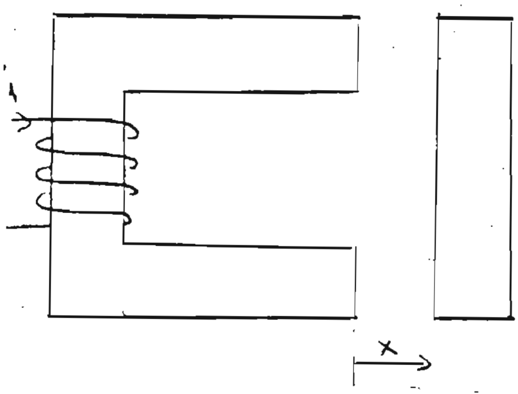
* For the electromechanical system shown, the coil current is expressed in terms of flux linkage and distance as

$$i = \lambda^2 + 2\lambda(x-1)^2 \text{ A} \quad \text{for } x<1$$

If the force produced on the moving part is 4 N when $x = 0.5$ cm, find the current drawn from the source for this particular condition.



$$W_{fld} = \int_0^{\lambda} i\, d\lambda = \int_0^{\lambda} [\lambda^2 + 2\lambda(x-1)^2]\, d\lambda$$

$$= \frac{1}{3}\lambda^3 + \lambda^2(x-1)^2$$

$$F_{fld} = -\frac{\partial W_{fld}(\lambda, x)}{\partial x} = -2\lambda^2(x-1)$$

At $x = 0.5$ cm

$$F_{fld} = \lambda^2 \Rightarrow \lambda^2 = 4$$

$$\lambda = 2$$

$$\Rightarrow i = 4 + 4(0.5)^2$$

$$= 5 \text{ A}$$

The electromagnet is to be used to lift a 120 kg slab of iron, as shown in the figure. The surface roughness of the iron and electromagnet are in contact, there is a minimum air gap of 0.1 cm in each leg. The coil resistance is 3Ω. Calculate the minimum coil voltage which must be used in order to lift the slab against the force of gravity, $g=9.8\ m/sec^2$. Neglect the reluctance of the iron.

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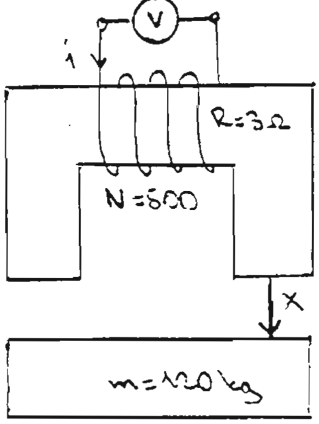

Cross sectional area = 25 cm²

$$W_{fld} = \frac{1}{2}\frac{(mmf)^2}{\mathcal{R}} = \frac{1}{2}\frac{N^2 i^2}{\frac{2\cdot x}{\mu_0 A}} = \frac{1}{4}\cdot\frac{N^2 i^2 \mu_0 A}{x}$$

$$F_{fld} = +\frac{1}{4}\cdot\frac{N^2 i^2 \mu_0 A}{x^2} = \frac{1}{4}\cdot\frac{500^2\cdot 4\pi\times10^{-7}\cdot 0.0025}{0.001^2}\, i^2 = 196.35\, i^2$$

$$F_{gravity} = 120\cdot 9.8 = 1176\ N$$

$$F_{fld} = F_{gravity}$$

$$\Rightarrow 1176 = 196.35\, i^2$$

$$i^2 \approx 6$$
$$i = \sqrt{6}\ A$$

$$V = I\cdot R$$
$$= \sqrt{6}\cdot 3$$

$V = 7.35$ Volts.