Phys-112, Final Exam Solutions 18 May 2007

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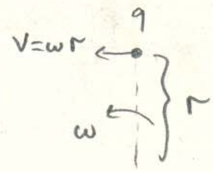
1] Consider a charge q on the rotating disk

a)



The motional emf bet $r=a$ to $r=R$

B

$$\mathcal{E} = \int_0^a \frac{q\vec{v}\times\vec{B}}{q}\cdot\vec{dl}$$

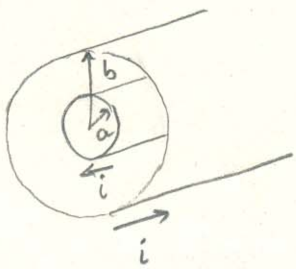
$$\mathcal{E} = \int_0^a B\omega r\,dr = \omega\frac{R^2 B}{2}$$

b) Using the power balance, $\underbrace{P_{mech}} = \underbrace{P_{elec.}}$

$$\tau\omega = \mathcal{E} i$$

$$\Rightarrow \tau = \frac{R^2 B i}{2}$$

2]



B field only exists in $b>r>a$:

$$B = \frac{\mu_0 i}{2\pi r}$$

Elsewhere $B \equiv 0$

Magnetic Energy Density: $u_B = \frac{1}{2\mu_0}B^2 = \frac{\mu_0 i^2}{8\pi^2 r^2}$

Total Magnetic Energy Per unit length: $\bar{U}_B = \int_a^b \frac{\mu_0 i^2}{8\pi^2 r^2}2\pi r\,dr = \frac{\mu_0 i^2}{4\pi}\ln(b/a)$

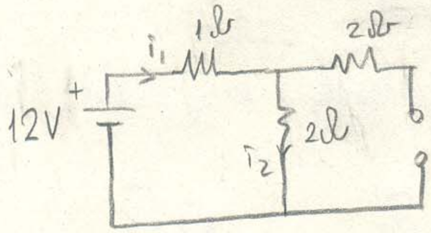
Using $\bar{U}_B = \frac{1}{2}\bar{L}i^2$, $\bar{L} = \frac{\mu_0}{2\pi}\ln(b/a)$

↑ inductance per unit length

3] The rationale for solving RL ccts with switches:

Since $v_L = L \frac{di_L}{dt}$, inductor current, $i_L(t)$ should be <u>continuous</u> during switchings. Also inductor goes to short circuit as $t \to \infty$

a) Just after S closed

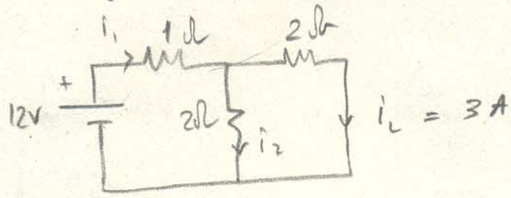


L: open circuit

↑ i_L is continuous

$$i_1 = i_2 = \frac{12}{1+2} = 4\,A$$

b) Long time after (a); L → short circuit



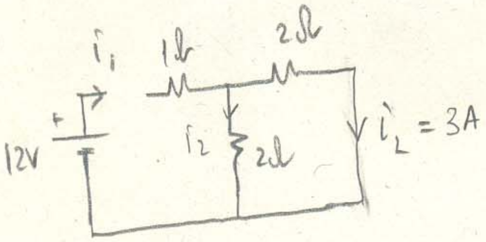
$i_1 = 6A, \quad i_2 = 3\,A$

The energy stored in the inductor

$$U_B = \frac{1}{2} L \left(I_{final}^2 - I_{initial}^2\right) = \frac{1}{2} \cdot 2 \cdot (3^2 - 0^2)$$

$$= 9\,J$$

c) S again opened : i_L continuous

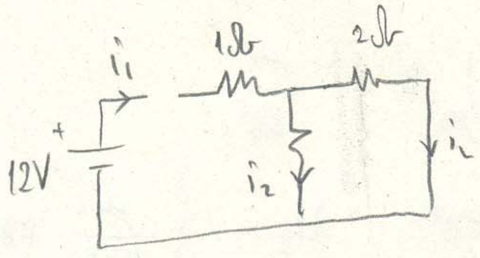


F.B.

$i_1 = 0\,A$

$i_2 = -i_L = -3\,A$

d) Long time afterwards : Inductor gets discharged $i_L \to 0$



$i_L \to 0$

$\Rightarrow i_2 \to 0$

$i_1 = 0$

4] a) The magnetization of a diamagnetic material is small but opposite to the external $\vec{B}$ field, whereas the magnetization of a paramagnet is a small but +ve value.

b) Lenz' law essentially states that the induced emf is in the direction, to oppose the change in the enclosed magnetic flux.

c) Mutual inductance is the coefficient that determines the amount of magnetic flux enclosed by one system (loop) due to a current flowing in another loop (circuit).

d) Permeability $\xrightarrow{[SI]}$ $\frac{H}{m}$

e) $\oint_S \vec{B} \cdot \hat{n} \, da \equiv 0$ ← as there is no isolated magnetic charge (magnetic monopole)