EM - Lecture 17

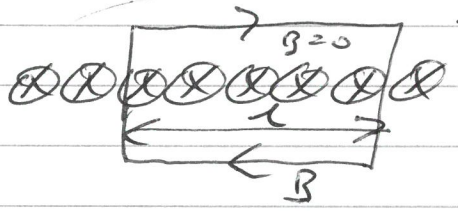
Ex 17-1

Inductance, L of a Solenoid

n turns / length , radius R

length l . Total turns, $N = nl$

$$L = \frac{N \Phi_m}{I} \quad (1)$$



$$\oint \underline{B} \cdot d\underline{l} = Bl$$

$$= \mu_0 I_{enc}$$

$$= \mu_0 N I$$

$$\therefore B = \frac{\mu_0 N I}{l} \quad (2)$$

flux thro' each turn $\Phi_m = \pi R^2 B$

Total flux, $N\Phi_m = (nl)\pi R^2 B$

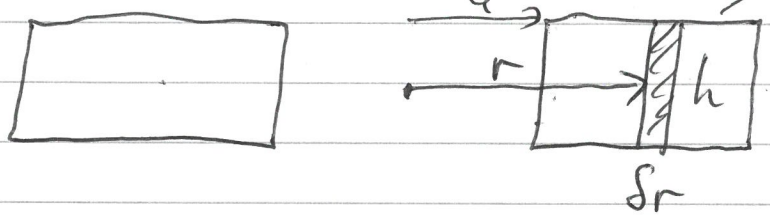
from (2) : $N\Phi_m = \frac{(nl)\pi R^2 \mu_0 N I}{l}$

$$N\Phi_m = n^2 l \pi R^2 \mu_0 I \quad \left(\frac{N}{l} = n\right)$$

From ① $L = N\phi_m / I$

$\therefore \underline{L = n^2 l \pi R^2 \mu_0}$

Ex 17.2 — L of Toroid



$B = \frac{\mu_0 N I}{2\pi r}$ $\quad \delta A = h\,\delta r$

$\therefore \delta\phi_m = \frac{\mu_0 N I h}{2\pi} \frac{\delta r}{r}$

Total flux, $\phi_m = \frac{\mu_0 N I h}{2\pi} \int_a^b \frac{dr}{r}$

$\phi_m = \frac{\mu_0 N I h}{2\pi} \ln\left(\frac{b}{a}\right)$

But $L = \frac{N\phi_m}{I} = \frac{\mu_0 N^2 h}{2\pi} \ln\left(\frac{b}{a}\right)$