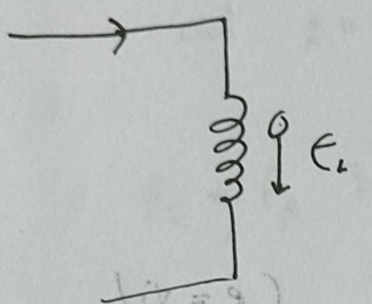
$0.2\,A \rightarrow \downarrow$ } $\frac{\text{in}}{2\,\text{sec}}$

$0.1\,A$

$0.0\,A$

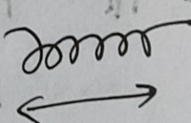
i decreasing $\quad 0.2 \rightarrow 0\,A$




$$|\epsilon_L| = L\frac{di}{dt}$$

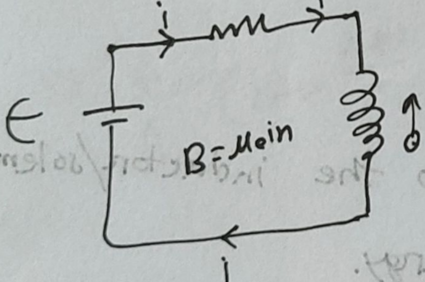
## RL Circuit

inductor/solenoid




$B = \mu_0 i n$

$n = \frac{N}{l}$




$$E_L = L\frac{di}{dt}$$

$i = 0,\ t = 0$

Applying kirchoff's Laws,

$$+\epsilon - iR - L\frac{di}{dt} = 0 \quad \text{---} \ (i)$$

$$i(t) = \frac{\epsilon}{R}\left(1 - e^{-Rt/L}\right) \quad \text{....} \ (ii)$$

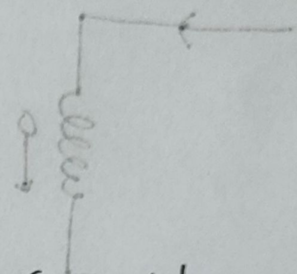
$\frac{L}{R} = \tau = \tau_L =$ Inductive Time constant.

$$\left(\epsilon - iR - L\frac{di}{dt} = 0\right) \times i \quad \text{--- (i)}$$

$$\epsilon i - i^2 R - Li\frac{di}{dt} = 0$$

$$\epsilon i = i^2 R + Li\frac{di}{dt} \quad \text{--- (3)}$$

$$P_\epsilon = P_R + P_B$$



$(P = Vi)$

$\epsilon i$ = Power supplied by battery

$\left(P = \frac{dv}{dt}\right)$

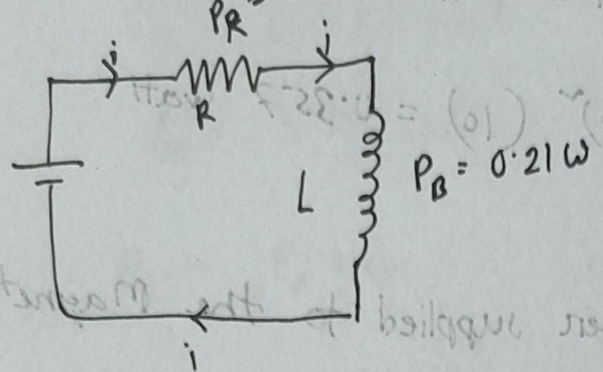
$\epsilon i = P_\epsilon$

$i^2 R = P_R$ = Power dissipated thru resister $R$ as joule heat

$Li\frac{di}{dt} = P_B$ = Power supplied to the inductor/solenoid as magnetic energy.

$$\boxed{P_\epsilon = P_R + P_B}$$

Example: $P_R = 0.357$ W




$\mathcal{E} = 3$ Volt

$R = 10\ \Omega$

$L = 3$ Henry

$\tau = \frac{L}{R} = \frac{3}{10} = 0.3$ sec

at $t = \tau = 0.3$ sec

$P_{\mathcal{E}}$, $P_R$ & $P_B$ ?

i) $P_e$ = Power supplied by the battery.

$P_{\mathcal{E}} = \mathcal{E} i$ $\qquad t = \tau = 0.3$ sec

$$i = \frac{\mathcal{E}}{R}\left(1 - e^{-\frac{Rt}{L}}\right) = \frac{3}{10}\left(1 - e^{-\frac{10}{3} \times 0.3}\right)$$

$$= \frac{3}{10}\left(1 - e^{-1}\right)$$

$i = 0.19$ Amp

$P_{\mathcal{E}} = \mathcal{E} i = 3 \times 0.19 = 0.567$ Watt

= Power supplied by the battery.

(ii) $P_R = i^2 R$ = Power loss thru resistor

$= (0.19)^2 (10) = 0.357$ watt

(iii) $P_B = Li \frac{di}{dt}$ = Power supplied to the Magnetic field in the inductor.

$i = 0.19A$

$i = \frac{E}{R}(1 - e^{-\frac{Rt}{L}})$

$\frac{di}{dt} = \frac{E}{R}(0 - e^{-\frac{Rt}{L}} \cdot (\frac{-R}{L}))$

$= \frac{E}{\cancel{R}}(e^{-Rt/L} \cdot \frac{\cancel{R}}{L})$

$\frac{di}{dt} = \frac{E}{L} e^{-Rt/L}$ at, $t = 0.3$ sec

$= \frac{3}{3} e^{-\frac{10}{3} \cdot 0.3}$

$= e^{-1} \approx 0.37$ A/sec

$P_B = Li\frac{di}{dt} = 3 (0.19)(0.37) = 0.21$ Watt

$P_E = 0.567$ Watt

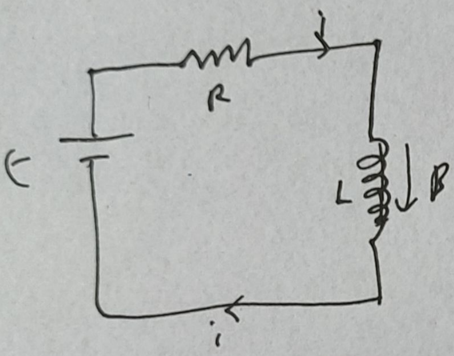
$P_R = 0.357$ watt

$P_B = 0.21$ watt

$P_E = P_R + P_B$

$0.567 = 0.35 + 0.21$

## R-L Circuit




$P_E = \mathcal{E} i$

$P_R = i^2 R$

$P_B = L i \frac{di}{dt}$

$U_B$ = Magnetic energy stored in the inductor

$U_B = \frac{1}{2} L i^2$ = Total energy

$u_B = \frac{1}{2\mu_0} B^2$ = energy density

$U_B = \frac{1}{2} L i^2$

$\text{Volume} = A l = \pi r^2 l$

$\text{Energy} = U_B = \frac{1}{2} L i^2$

$$u_B = \frac{U_B}{\text{Volume}} = \frac{1}{2} \frac{L i^2}{A l} = \frac{1}{2\mu_0} B^2$$

$\boxed{\text{END}}$