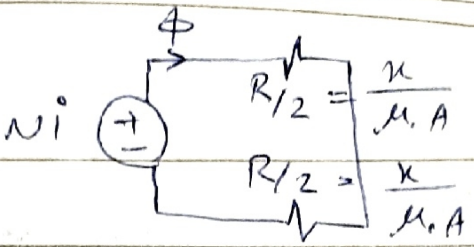
(1)



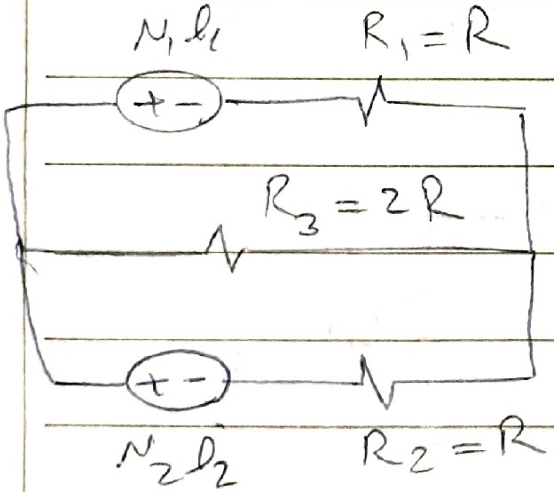

$$R = \frac{2x}{\mu_0 A}$$

$$\Phi = \frac{Ni}{R} = \frac{Ni\mu_0 A}{2x} \Rightarrow \lambda = N\Phi = \frac{N^2 i \mu_0 A}{2x}$$

$$\left.\begin{array}{l} e = \frac{d\lambda}{dt} = \frac{d}{dt}\left(\frac{N^2 i \mu_0 A}{2x}\right) \\ x = v.t \end{array}\right\} \Rightarrow e = \frac{N^2 i \mu_0 A}{2v}\frac{d}{dt}\left(\frac{1}{t}\right)$$

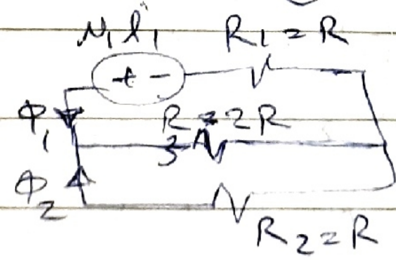
$$\Rightarrow e = -\frac{N^2 i \mu_0 A}{2vt^2} \times \frac{v}{v} = -\frac{N^2 i \mu_0 A v}{2v^2t^2} = \boxed{-\frac{N^2 i \mu_0 A v}{2x^2}}$$

(2)




$$R = \frac{x/2}{\mu_0 A} = \frac{x}{2\mu_0 A}$$

③ $L_{11}$ : همه منابع به جز $i_1$ خاموش:




$$L_{11} = \frac{\lambda_1}{i_1}$$

$$R_T = \underbrace{(R_2 \| R_3)}_{\frac{2}{3}R} + R_1 = \frac{5}{3}R$$

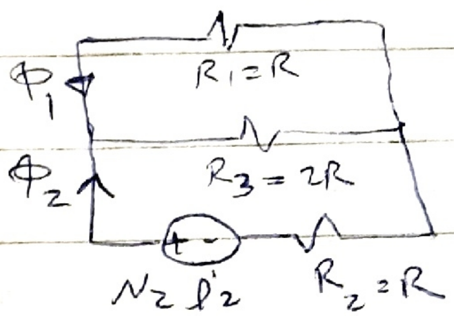
$$\lambda_1 = N_1\Phi_1 = N_1\left(\frac{N_1 i_1}{\frac{5}{3}R}\right)$$

$$\boxed{L_{11} = \frac{\lambda_1}{i_1} = \frac{3N_1^2}{5R}}$$

ادامه (2)

ب) $L_{12}$ : همه منابع بجز $N_2 i_2$ را صفر می‌کنیم

$$L_{12} = \frac{\lambda_1}{i_2}$$




$$R_T = (R_1 \| R_3) + R_2 = \frac{5}{3} R$$

$$\Phi_2 = \frac{3 N_2 i_2}{5R}$$

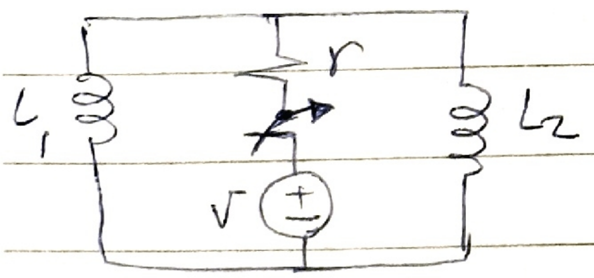
تقسیم جریان (شبیه به تقسیم جریان در مدار الکتریکی)

$$\Phi_1 = -\Phi_2 \times \frac{R_3}{R_1 + R_3}$$

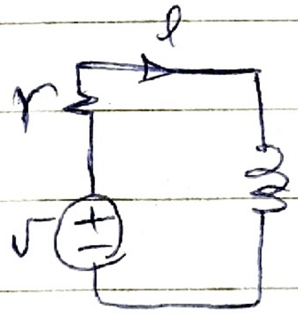
$$\Phi_1 = \frac{3N_2 i_2}{5R} \times \frac{2R}{3R} = \frac{-2 N_2 i_2}{5R} \Rightarrow \lambda_1 = N_1 \Phi_1 = \frac{-2 N_1 N_2 i_2}{5R}$$

$$\boxed{L_{12} = \frac{\lambda_1}{i_2} = -\frac{2 N_1 N_2}{5R}} \Rightarrow \boxed{\frac{L_{12}}{L_{11}} = -\frac{2}{3} \frac{N_2}{N_1}}$$

(3)



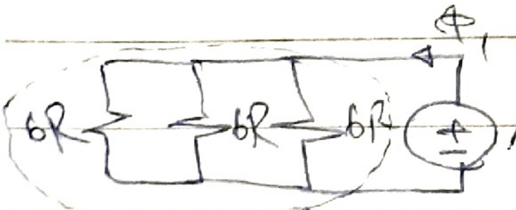

$\Rightarrow$




مدار الکتریکی:

$$L_1 \| L_2 = L_{eq}$$

مدار مغناطیسی سمت چپ:

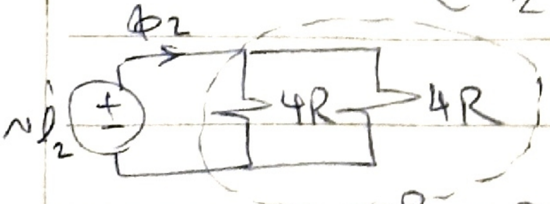



$$R = \frac{g}{\mu_0 A}$$

$$R_T = 6R \| 6R \| 6R = 2R$$

$$\lambda_1 = N_1 \Phi_1 = N\left(\frac{N i_1}{2R}\right) \Rightarrow L_1 = \frac{\lambda_1}{i_1} = \boxed{\frac{N^2}{2R}}$$

مدار مغناطیسی سمت راست:




$$R = \frac{g}{\mu_0 A}$$

$$R_T = 2R$$

$$\lambda_2 = N_2 \Phi_2 = N\left(\frac{N i_2}{2R}\right) \Rightarrow L_2 = \frac{\lambda_2}{i_2} = \boxed{\frac{N^2}{2R}} \Rightarrow \boxed{L_{eq} = L_1 \| L_2 = \frac{N^2}{4R}}$$

ادامه 3

حل معادله دیفرانسیل مرتبه اول : (مدار RL)

$$V = ri + L_{eq}\frac{di}{dt} \Rightarrow \frac{di}{dt} + \frac{r}{L_{eq}} i = \frac{V}{L_{eq}}$$ معادله دیفرانسیل ناهمگن

حل معادله همگن

$$\frac{di}{dt} + \frac{r}{L_{eq}} i = 0$$

معادله مشخصه :

$$S + \frac{r}{L_{eq}} = 0 \longrightarrow \boxed{S = \frac{-r}{L_{eq}}}$$

پاسخ عمومی :

$$\boxed{i_h = k e^{-r/L_{eq}\, t}}$$

پاسخ خصوصی :

$$0 + \frac{r}{L_{eq}} i_p = \frac{V}{L_{eq}} \Rightarrow \boxed{i_p = \frac{V}{r}}$$

$$i(t) = i_h + i_p = k e^{-r/L_{eq}\, t} + \frac{V}{r}$$ با شرط اولیه $i(0)=0$ ثابت k را بدست می‌آوریم :

$$k + \frac{V}{r} = 0 \Rightarrow \boxed{k = -\frac{V}{r}}$$

معادله زمانی جریان (i) :

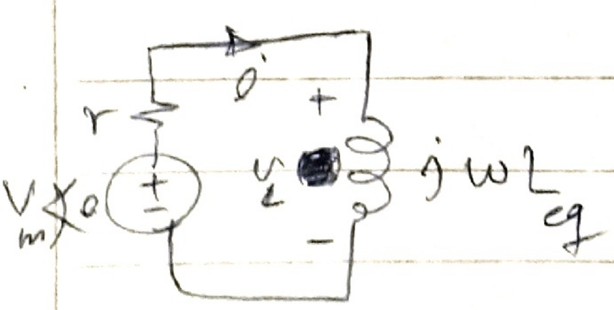
$$\boxed{i(t) = \frac{V}{r}\left(1 - e^{-r/L_{eq}\, t}\right)}$$

معادله زمانی ولتاژ سلف

$$V_L(t) = L_{eq}\frac{di}{dt} = L_{eq}\frac{d}{dt}\left[\frac{V}{r}\left(1 - e^{-r/L_{eq}\, t}\right)\right] = \boxed{V e^{-r/L_{eq}\, t}}$$

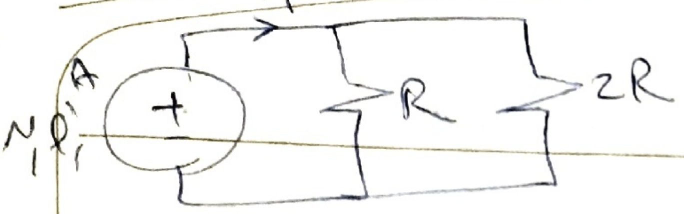
پاسخ (الف)

پاسخ (ب)




$$V_L = \frac{j\omega L_{eq}}{r + j\omega L_{eq}}(V_m\angle 0) = \frac{\omega L_{eq}}{\sqrt{r^2 + \omega^2 L_{eq}^2}} \cdot V_m \angle \left(90 - tg^{-1}\left(\frac{\omega L_{eq}}{r}\right)\right)$$

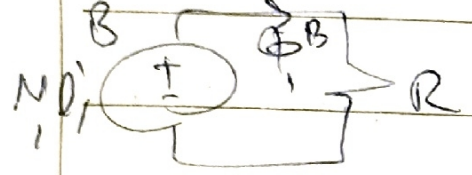
(4) آزمایش اول




$R = \frac{g}{\mu_0 A}$

$$\Phi_1^A = \frac{N_1 i_1'^A}{R \| 2R} = \frac{N_1 i_1'}{\frac{2}{3} R} \Rightarrow \boxed{i_1'^A = \frac{2R\Phi_1^A}{3N_1}}$$

آزمایش دوم



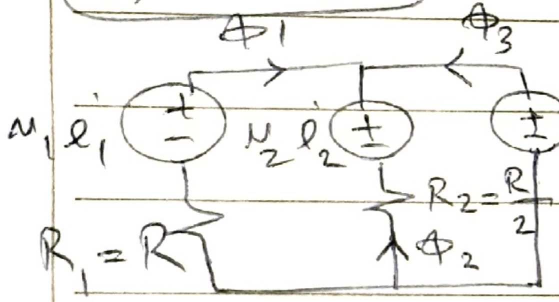

$$\Phi_1^B = \frac{N_1 i_1'^B}{R} \Rightarrow \boxed{i_1'^B = \frac{R\Phi_1^B}{N_1}}$$

$$e = \frac{d\lambda}{dt} \Rightarrow \Phi_1^A = \Phi_1^B = \frac{1}{N}\int e\,dt = \frac{-V_m}{NW}\cos wt$$

دامنه ها برابر است

$$\boxed{\frac{i_1'^A}{i_1'^B} = \frac{2}{3}}$$

(5)




$R = \frac{x}{\mu_0 W d}$

$$-N_1 I_1 + R\Phi_1 + N_3 I_3 = 0 \Rightarrow \Phi_1 = \frac{N_1}{R} I_1 - \frac{N_3}{R} I_3$$

$$-N_2 I_2 + \frac{R}{2}\Phi_2 + N_3 I_3 = 0 \Rightarrow \Phi_2 = \frac{N_2}{R/2} I_2 - \frac{N_3}{R/2} I_3$$

$$\Phi_3 = -(\Phi_1 + \Phi_2) = -\frac{N_1}{R} I_1 - \frac{N_2}{R/2} I_2 + \frac{3N_3}{R} I_3$$

$$\lambda_1 = \underbrace{\frac{N_1^2}{R}}_{L_{11}} I_1 + \underbrace{\frac{-N_1 N_3}{R}}_{L_{13}} I_3 \qquad L_{12} = 0$$

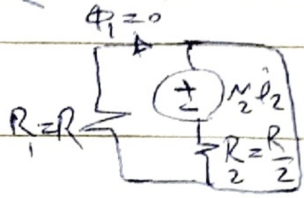
$$\lambda_2 = \underbrace{\frac{2N_1 N_2}{R}}_{L_{22}} I_2 + \underbrace{\frac{-2N_3}{R}}_{L_{23}} I_3 \qquad L_{21} = 0$$

$$\lambda_3 = \underbrace{\frac{-N_1 N_3}{R}}_{L_{31}} I_1 + \underbrace{\frac{-2N_2 N_3}{R}}_{L_{32}} I_2 + \underbrace{\frac{3N_3^2}{R}}_{L_{33}} I_3$$

ادامه 5 روش دوم:

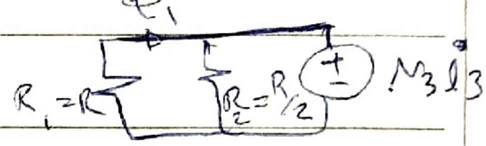
$$L_{lj} = \frac{\lambda_l}{i_j}\Big|_{\text{سایر منابع خاموش}}$$


$$L_{11} = \frac{\lambda_1}{i_1}\Big|_{\substack{i_2, i_3 = 0 \\ \text{خاموش}}} = \frac{N_1 \Phi_1}{I_1} = \frac{N_1 \frac{N_1 I_1}{R}}{I_1} = \frac{N_1^2}{R}$$




$$L_{12} = \frac{\lambda_1}{i_2}\Big|_{i_1, i_3 = 0} = \frac{N_1 \Phi_1}{I_2} = \frac{N_1 \times 0}{I_2} = 0$$

$$L_{13} = \frac{\lambda_1}{i_3}\Big|_{i_1, i_2 = 0} = \frac{N_1 \Phi_1}{I_3} = \frac{N_1 \frac{-N_3 I_3}{R}}{I_3} = \frac{-N_1 N_3}{R}$$

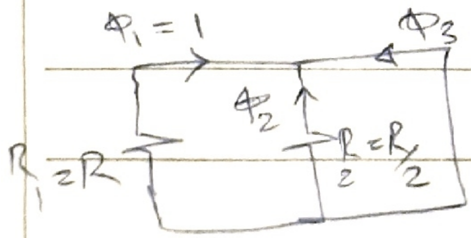



روش سوم

$$L_{lj} = \pm L_{ll} \frac{N_j}{N_l} q_{lj}$$

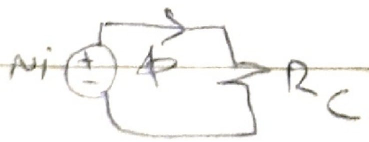
$$L_{13} = -N_1 \frac{N_1}{R} \cdot \frac{N_3}{N_1} \cdot 1 = -\frac{N_1 N_3}{R}$$

که $q$ : شارش فضایی که سیم پیچ $l$ درک وجود دارد برابر یک وبر لحاظ شده و شار سیم پیچ $j$ را بدست می‌آوریم




$$\Phi_3 = -1 \ wb$$

6 طرح سوم/مسئله

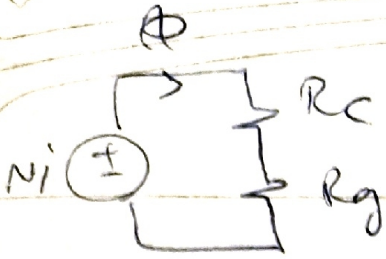



$$l_c = 4 \times 30 = 120 \ cm$$

$$R_C = \frac{l_c}{\mu_c A_c} = \frac{120 \times 10^{-2}}{2000 \times 4\pi \times 10^{-7} \times 10 \times 5 \times 10^{-4}} = 95.49 \times 10^3 \ At/wb$$

$$\Phi = \frac{400 \times 1.5}{95.49 \times 10^3} = 6.2832 \times 10^{-3} \ wb$$

$$B = \frac{6.2832 \times 10^{-3}}{10 \times 5 \times 10^{-4}} = 1.257 \ T \quad , \quad L = \frac{N^2}{R_C} = \frac{400^2}{95.49 \times 10^3} = 1.6756 \ H$$




$$R_c = \frac{(120-1)\times 10^{-2}}{2000\times 4\pi\times 10^{-7}\times 50\times 10^{-4}} = 94.697\times 10^{3}$$

(7)

$$R_g = \frac{[redacted]1\times 10^{-2}}{4\pi\times 10^{-7}\times 50\times 10^{-4}\times 1.1} = 1446.86\times 10^{3}$$

$$\Phi = \frac{400\times 1.5}{(94.697+1446.86)\times 10^{3}} = 0.3892\times 10^{-3}$$

$$B = \frac{0.3892\times 10^{-3}}{50\times 10^{-4}} = 0.078 \text{ T}$$

$$L = \frac{400^2}{R_c+R_g} = \frac{400^2}{1541.56\times 10^{3}} = 0.1038 \text{ H}$$

(8)

$$\lambda = Li$$

$$N\Phi = Li$$

$$NBA = Li \Rightarrow N = \frac{Li}{BA} = \frac{1.4\times 10^{-3}\times 6}{1.7\times 5\times 10^{-4}} = \boxed{99 \text{ Turns}}$$

$$\Phi = \frac{Ni}{R_c+R_g} = B\cancel{A} \Rightarrow \frac{1}{B} = \frac{\frac{l_g}{\mu_0}+\frac{l_c}{\mu}}{Ni}$$

$$\frac{l_c}{\mu \cancel{A}} \qquad \frac{l_g}{\mu_0 \cancel{A}}$$

$$\Rightarrow l_g = \frac{\mu_0 N i}{B} - \frac{\mu_0 l_c}{\mu} = \boxed{0.36 \text{ mm}}$$