3-11

解

$$\begin{aligned}\mathscr{E} &= \int_a^b \frac{v\mu_0 I\,\mathrm{d}r}{2\pi r} \\ &= \frac{v\mu_0 I}{2\pi}\ln\frac{b}{a} \\ &= 3.7\times 10^{-5}\mathrm{V}\end{aligned}$$

a 端电势高

3-13

解 (1)

$$\begin{aligned}\mathscr{E} &= \int_0^R \omega r B\,\mathrm{d}r \\ &= \frac{\omega B R^2}{2}\end{aligned}$$

(2) 从 b 到 a

(3)

$$\begin{aligned}L &= \int_0^R rBI dr \\ &= \frac{BIR^2}{2}\end{aligned}$$

方向垂直纸面向里

(4) 会

(5) 相当于多个电阻并联，感应电动势不变

3-30

解 (1) 取半径为 $r(\frac{D_2}{2} < r < \frac{D_1}{2})$ 的环形回路，由对称性知该环路上的磁感应强度均沿切向，则由安培环路定理知

$$2\pi r B = \mu_0 N I$$

则

$$B = \frac{\mu_0 N I}{2\pi r}$$

$$\begin{aligned}\Phi_B &= \int_{\frac{D_2}{2}}^{\frac{D_1}{2}} Bh\,\mathrm{d}r \\ &= \int_{\frac{D_2}{2}}^{\frac{D_1}{2}} \frac{\mu_0 N I}{2\pi r} h\,\mathrm{d}r \\ &= \frac{\mu_0 N I h}{2\pi}\ln\frac{D_1}{D_2}\end{aligned}$$

$$\begin{aligned}\Psi &= N\Phi_B \\ &= \frac{\mu_0 N^2 I h}{2\pi}\ln\frac{D_1}{D_2}\end{aligned}$$

故自感系数为

$$\begin{aligned}L &= \frac{\Psi}{I} \\ &= \frac{\mu_0 N^2 h}{2\pi}\ln\frac{D_1}{D_2}\end{aligned}$$

(2)

$$L = \frac{4\pi\times10^{-7}\times1000\times1000\times0.01}{2\pi}\ln\frac{0.2}{0.1}\mathrm{H} = 1.4\times10^{-3}\mathrm{H}$$

3-34

解

$$\begin{cases} L_1 + L_2 + 2M = 1\mathrm{H} \\ L_1 + L_2 - 2M = 0.4\mathrm{H}\end{cases}$$

解得 $M = 0.15\mathrm{H}$

3-35

解 (1)

$$B = \frac{\mu_0 NI}{2\pi r} + \frac{\mu_0 I}{2\pi(d-r)}$$

$$\begin{aligned}\Phi &= \int_a^{d-a} B\,\mathrm{d}r \\ &= \frac{\mu_0 I}{\pi}\ln\frac{d-a}{a}\end{aligned}$$

自感系数

$$L = \frac{\Phi}{I} = \frac{\mu_0}{\pi}\ln\frac{d-a}{a}$$

因为 $a \ll d$ 故

$$L \approx \frac{\mu_0}{\pi}\ln\frac{d}{a}$$

故

$$L = \frac{4\pi\times10^{-7}}{\pi}\ln\frac{200}{1}\mathrm{H} = 2.1\times10^{-6}\mathrm{H}$$

(2)

$$\begin{aligned} A &= \int F \,\mathrm{d}r \\ &= \int_d^{2d} \frac{\mu_0 I^2}{2\pi r} \,\mathrm{d}r \\ &= \frac{\mu_0 I^2}{2\pi} \ln 2 \\ &= 5.5 \times 10^{-5}\mathrm{J} \end{aligned}$$

(3)

$$\begin{aligned} \Delta W &= W_2 - W_1 \\ &= \frac{L_2 I^2}{2} - \frac{L_1 I^2}{2} \\ &\frac{1}{2}(\frac{\mu_0}{\pi} \ln \frac{2d}{a} - \frac{\mu_0}{\pi} \ln \frac{d}{a}) \\ &= \frac{\mu_0 I^2}{\pi} \ln 2 \\ &= 5.5 \times 10^{-5}\mathrm{J} \end{aligned}$$

能量增加,来自电源