7.1. (1) $\varepsilon = -\frac{d\Phi}{dt} = -\frac{d\,B a\cdot vt}{dt} = -Bav.$

$F = BIa = B\frac{\varepsilon}{R}a = \frac{B^2a^2v}{R}$ 向上

(2)

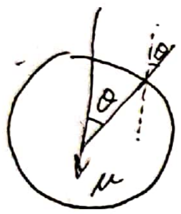
$B = \frac{\mu_0 I}{2\pi r}$ 向里.

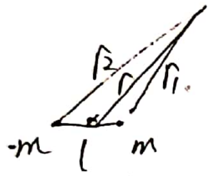
$= \frac{\mu_0 I}{2\pi vt}$

$\Phi = \iint B\cdot ds = \int_{vt}^{vt+b} \frac{\mu_0 I}{2\pi r}\cdot a\cdot dr = \frac{\mu_0 I a}{2\pi}\ln\frac{vt+b}{vt}.$

$\varepsilon = -\frac{d\Phi}{dt} = \frac{\mu_0 I a}{2\pi}\frac{-1}{\frac{vt+b}{vt}}\cdot\frac{v^2t - v^2t - bv}{(vt)^2} = \frac{\mu_0 I a}{2\pi}\cdot\frac{b}{(vt+b)t}.$

7.2.





$\Psi = \Psi_1 + \Psi_2 = \frac{m}{4\pi\mu_0 r_1} + \frac{-m}{4\pi\mu_0 r_2} = \frac{m}{4\pi\mu_0}\left(\frac{1}{r-\frac{l}{2}\cos\theta} - \frac{1}{r+\frac{l}{2}\cos\theta}\right)$

$= \frac{m}{4\pi\mu_0 r}\left(\frac{\frac{l}{r}\cos\theta}{1-\frac{l^2}{4r^2}\cos^2\theta}\right) \approx \frac{ml}{4\pi\mu_0 r^2}\cos\theta = \frac{\vec{p}\cdot\vec{r}}{4\pi\mu_0 r^3}.$

$H = -\nabla\Psi = \frac{1}{4\pi\mu_0}\frac{2p\cos\theta}{r^3}\vec{e_r} + \frac{1}{4\pi\mu_0}\frac{p\sin\theta}{r^3}\vec{e_\theta}$

$\to \vec{B_r} = \frac{\mu_0\mu\cos\theta}{2\pi r^3}\vec{e_r}.$

$\vec{B_\theta} = \frac{\mu_0\mu\sin\theta}{4\pi r^3}\vec{e_\theta}.$

$\varepsilon = \int_0^{\frac{\pi}{2}} \vec{v}\times\vec{B}\cdot d\vec{l} = \int_0^{\frac{\pi}{2}} \omega R\sin\theta\,\vec{e_\varphi} \times \left(-\frac{\mu_0\mu\cos\theta}{2\pi R^3}\vec{e_r} - \frac{\mu_0\mu\sin\theta}{4\pi R^3}\vec{e_\theta}\right)\cdot R\,d\theta\,\vec{e_\theta}$

$= -\int_0^{\frac{\pi}{2}} \frac{\omega\sin\theta\cos\theta\,\mu_0\mu}{2\pi R}\,d\theta = -\frac{\omega\mu_0\mu}{4\pi R}.$

7.4.(1) $\varepsilon = \int_0^a \vec{v}\times\vec{B}\cdot d\vec{l} = \int_0^a \omega r\cdot B\cdot dr = \frac{\omega B a^2}{2}$.

(2) $R_内 = \frac{r}{4}$. $R=\frac{r}{4}$时. $P_{max} = \frac{\omega^2 B^2 a^2}{4r}$.

7.5.(1) $\varepsilon = \vec{v}\times\vec{B}\cdot a = 0.62\times10^{-4}\times\frac{6\times10^4}{3600}\times2.5 \approx 2.58\times10^{-3}$ V.

(2) $qVB = qE \rightarrow E = BV = 0.62\times10^{-4}\times\frac{6\times10^4}{3600} \approx 1.03\times10^{-3}$ V/m.

(3). $\sigma = \frac{Q}{S} = \frac{\varepsilon_0 S\cdot E}{S} = \varepsilon_0\cdot E = 8.85\times10^{-12}\times1.03\times10^{-3} \approx 9.12\times10^{-15}$ c/m².

7.9 (1). $2\pi r B = \mu_0 N I \rightarrow B = \frac{\mu_0 N I}{2\pi r}$.

$\Phi = \iint B\cdot dS = \int_{R-a}^{R+a}\frac{\mu_0 N I}{2\pi r}\cdot h\cdot dr = \frac{\mu_0 N I h}{2\pi}\ln\frac{R+a}{R-a}$.

$= LI$.

$L = \frac{\mu_0 N h}{2\pi}\ln\frac{R+a}{R-a}$.

(2). $\psi = \int_{R-a}^{R+a}\frac{\mu_0 I}{2\pi r}\cdot h\cdot dr = \frac{\mu_0 I h}{2\pi}\ln\frac{R+a}{R-a}$.

$M = \frac{\psi}{I} = \frac{\mu_0 h}{2\pi}\ln\frac{R+a}{R-a}$.

7.10 (1). $R_铁 = \frac{l}{\mu S} = \frac{2\pi r - d}{\mu_0\mu_r\cdot S}$. $R_气 = \frac{d}{\mu_0 S}$.

$\Phi = \frac{NI}{R} = \frac{NI}{R_铁+R_气} = \frac{\mu_0\mu_r S N I}{2\pi r - d + \mu_r d}$

$B\cdot S = \Phi \rightarrow B = \frac{\mu_0\mu_r N I}{2\pi r - d + \mu_r d} = \frac{4\pi\times10^{-7}\times700\times1200\times1}{2\pi\times0.1 - 0.001 + 700\times0.001} \approx 0.8$ T.

(2). $L = \frac{\Phi}{I} = \frac{\mu_0\mu_r S N}{2\pi r - d + \mu_r d} = \frac{4\pi\times10^{-7}\times700\times12\times10^{-4}\times1200}{2\pi\times0.1 + 699\times0.001} \approx 1\times10^{-3}$ H.

7.11 $\omega_0=\frac{1}{\sqrt{LC}}$.

$$L=\frac{\Phi}{I}=\frac{BS}{I}=\frac{B\pi R^2}{I}=\frac{\frac{\mu_0 I}{l}\pi R^2}{I}=\frac{\mu_0\pi R^2}{l}.$$

$$C=\frac{Q}{U}=\frac{\varepsilon_0 a l Q}{Qd}=\frac{\varepsilon_0 a l}{d}.$$

$$\omega_0=\frac{\sqrt{dl}}{\sqrt{\mu_0\pi R^2\varepsilon_0 a l}}=\sqrt{\frac{d}{\mu_0\pi R^2\varepsilon_0 a}}.$$

7.13.

(1). $R_{铁}=\frac{2\pi b-\omega}{\mu S}$. $R_{气}=\frac{\omega}{\mu_0 S}$.

$$\rho\frac{N\cdot 2\pi a}{\pi r^2}=R=\frac{V}{I}\rightarrow I=\frac{V r^2}{N\rho 2a}$$

$$\Phi=\frac{NI}{R_{磁}}=\frac{Vr^2}{2\rho a\left(\frac{2\pi b-\omega}{\mu S}+\frac{\omega}{\mu_0 S}\right)}=\frac{Vr^2\mu\mu_0 S}{2\rho a(2\pi b\mu_0-\omega\mu_0+\mu\omega)}$$

$$B=\frac{\Phi}{S}=\frac{Vr^2\mu\mu_0}{2\rho a(2\pi b\mu_0-\omega\mu_0+\mu\omega)}.$$

(2). $P=VI=\frac{V^2 r^2}{N\rho 2a}$

(3). $V=L\frac{dI}{dt}=IR$.

$$L\frac{dI}{dt}+IR=0.\rightarrow \tau=\frac{L}{R}=\frac{B\pi a^2}{IR}=\frac{Vr^2\mu\mu_0\cdot\pi a^2}{2\rho a(2\pi b\mu_0-\omega\mu_0+\mu\omega)}\cdot\frac{N\rho 2a}{Vr^2}\frac{\pi r^2}{\rho N 2\pi a}$$

$$=\frac{r^2\mu\mu_0\pi a^2}{2\rho(2\pi b\mu_0-\omega\mu_0+\mu\omega)}.$$

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8.2 (1). $B=\frac{\mu_0 I}{2\pi r}$.

$$\Phi=\int_a^b \frac{\mu_0 I}{2\pi r}\cdot dr=\frac{\mu_0 I}{2\pi}\ln\frac{b}{a}.$$

$$L=\frac{\mu_0}{2\pi}\ln\frac{b}{a}.$$

(2). $W=\frac{L}{2}I^2=\frac{\mu_0}{4\pi}I^2\ln\frac{b}{a}$

$b_1\to 2b$

$W_1=\ln 2\, W$ $\quad \Delta W=W_1-W=\ln 2\,\frac{\mu_0}{4\pi}I^2$.

(3). 电池做功 $W_1=\int \varepsilon I\,dt=\int\frac{d\varphi}{dt}\cdot I\cdot dt=\int_b^{2b} I\cdot d\varphi=I\cdot\frac{\mu_0 I}{2\pi}\left(\ln\frac{2b}{a}-\ln\frac{b}{a}\right)$ $=\frac{\mu_0 I^2}{2\pi}\ln 2$.

磁场力做功 $W_2=\int F\cdot dl=\cancel{\int_b^{2b}\frac{\mu_0 I^2}{2\pi r}dr=\frac{\mu_0 I^2}{2\pi}\ln 2}$

$=\int_b^{2b} B\cdot I\cdot dl \quad \int_b^{2b}\left(\frac{\mu_0 I}{2\pi r}-\frac{\mu_0 I}{4\pi r}\right)\cdot I\cdot dl=\frac{\mu_0 I^2}{4\pi}\ln 2.$ $\quad W_1=W_2+\Delta W$

8.3 $\Psi_{12}=\iint\frac{\mu_0 I}{2\pi r}\cdot dS=\cancel{\int_d^{d+2R}\frac{\mu_0 I}{2\pi r}\cdot 2\sqrt{R^2-(R-(r-d))^2}\,dr}=\cancel{\frac{\mu_0 I}{\pi}\int_d^{d+2R}\frac{\sqrt{2(r-d)-(r-d)^2}}{r}dr}$

$$=\frac{\mu_0 I}{2\pi}\int_0^R\int_0^{2\pi}\frac{\rho\,d\theta\,d\rho}{d+\rho\cos\theta}=\cancel{\frac{\mu_0 I}{2\pi}\int_0^{2\pi}\frac{d\theta}{d+\rho\cos\theta}}$$

$$=\frac{\mu_0 I}{2\pi}\int_0^R\frac{\rho\,d\rho}{\sqrt{d^2-\rho^2}}\cdot 2\times 2\left(\frac{\pi}{2}-0\right)=\mu_0 I\left(d-\sqrt{d^2-R^2}\right)$$

$$W=I_1\Psi_{12}=I_2\Psi_{21}=\mu_0 I_1 I_2\left(d-\sqrt{d^2-R^2}\right).$$

8.4 (1) 由7.2: $B_r = \frac{\mu_0 m\cos\theta}{2\pi(b^2+z^2)^{\frac{3}{2}}}$

→高斯面等效: $\Phi = \iint B_r (b^2+z^2)\sin\theta \cdot d\theta \cdot d\varphi$

$$= \frac{\mu_0 m\cos\theta}{2\pi(b^2+z^2)^{1/2}} \int_0^{2\pi}\int_0^{\theta_0} \cos\theta\sin\theta \cdot d\theta \cdot d\varphi$$

$$= \frac{\mu_0 m}{2\sqrt{b^2+z^2}} \left. -\frac{\cos 2\theta}{2}\right|_0^{\theta_0} = \frac{\mu_0 m}{2\sqrt{b^2+z^2}}\left(\frac{1}{2}-\frac{1}{2}+\sin^2\theta_0\right)$$

$$= \frac{\mu_0 m}{2\sqrt{b^2+z^2}} \cdot \frac{b^2}{b^2+z^2} = \frac{\mu_0 m b^2}{2(b^2+z^2)^{3/2}}.$$

$$I = \frac{\Phi}{L} = \frac{\mu_0 m b^2}{2L(b^2+z^2)^{3/2}}$$

(2) $W = \Phi I = \frac{\mu_0^2 m^2 b^4}{4L(b^2+z^2)^3}$.