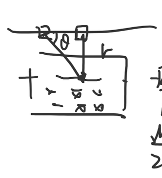
课后题

2022年5月17日 星期二　　下午3:15

1.(1) $\varepsilon = \frac{d\Phi}{dt} = \frac{dB\,ab}{dt} = Bav$

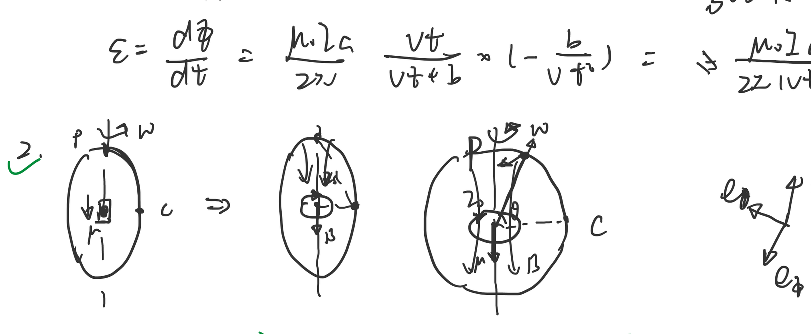
$I = \frac{\varepsilon}{R}$，$\vec F = B I d\vec l \times \vec l = BIa = \frac{B^2a^2v}{R}$ 方向

(2)


$\frac{\mu_0}{4\pi}\frac{Idl}{r^2} \to \int_0^{\pi} \frac{\mu_0}{4\pi} \frac{I\frac{r}{s\theta}d\theta}{(\frac{r}{s\theta})^2} = \frac{\mu_0 I}{4\pi r}\int_0^{\pi} s\theta\, d\theta = \frac{\mu_0 I}{2\pi r}$，$B = \frac{\mu_0 I}{2\pi r}$

$\Phi = \int_{vt}^{vt+b} \frac{\mu_0 I}{2\pi r} a\,dr = \frac{\mu_0 I a}{2\pi}\ln\frac{vt+b}{vt}$　$= 1 + \frac{b}{vt}$ 方向顺。

$\varepsilon = \frac{d\Phi}{dt} = \frac{\mu_0 I a}{2\pi}\frac{vt}{vt+b}\times(-\frac{b}{vt^2}) = \frac{\mu_0 I ab}{2\pi(vt+b)t}$

2.


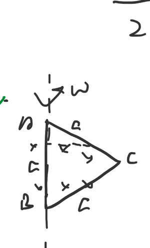
$\vec m = -m\vec e_z$，$\vec B = \frac{\mu_0 m\cos\theta}{2\pi r^3}\vec e_r - \frac{\mu_0 m\sin\theta}{4\pi r^3}\vec e_\theta$

$\varepsilon = \int_a^b (\vec v \times \vec B)\, d\vec l$

$= \int_0^{\frac{\pi}{2}} wR s\theta\, \vec e_\varphi \times (-\frac{\mu_0 m c\theta}{2\pi R^3}\vec e_r - \frac{\mu_0 m s\theta}{4\pi r^3}\vec e_\theta)\,d\theta \cdot \vec e_\theta R$

$= \int_0^{\frac{\pi}{2}} -wR s\theta \frac{\mu_0 m c\theta}{2\pi R^3}\vec e_\theta + wR s\theta \frac{\mu_0 m c\theta}{4\pi R^3}\vec e_r\, d\theta \cdot \vec e_\theta R$

$= \frac{-w\mu_0 m}{2\pi R^2}\int_0^{\frac{\pi}{2}} s\theta c\theta\, \vec e_\theta\, d\theta + \frac{w\mu_0 m}{4\pi R^2}\int_0^{\frac{\pi}{2}} s\theta\, d\theta$

3.


U_{AB}

$\varepsilon_1 = \int_0^a w\frac{\sqrt3}{2} r s\theta \frac{\sqrt3}{2}B\,dr$

$= \frac{1}{2} w a^2 \times \frac{\sqrt3}{2} s\theta B = \frac{\sqrt3}{8}Bwa^2 s\theta$ → 20条.

$\varepsilon_2 = \frac{d\Phi}{dt} = \frac{dB\frac{\sqrt3}{4}a^2 c\theta}{dt} = -\frac{\sqrt3 a^2}{4}B s\theta\frac{d\theta}{dt} = -\frac{\sqrt3 Bwa^2}{4}s\theta$

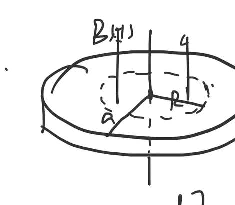
$U_{AB} = -\frac{\sqrt3}{12}Bwa^2 s\theta$

$U_{BC} = -\frac{\sqrt3}{12}Bwa^2 s\theta - \frac{\sqrt3}{8}Bwa^2 s\theta$

$U_{AC} = \frac{\sqrt3}{12}Bwa^2 s\theta + \frac{\sqrt3}{8}Bwa^2 s\theta$

$I = \frac{\varepsilon}{R} = \frac{\frac{\sqrt3}{4}Bwa^2 s\theta}{R}$，$IR = U_{AB} + \varepsilon_{AB}$ 20条.

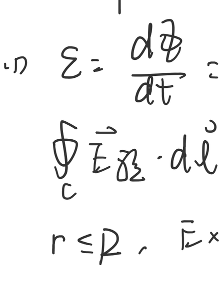
$\therefore V_{AC} = \frac{1}{3}IR - \varepsilon_{BC} = \frac{\sqrt3}{12}Bwa^2 s\theta - \frac{\sqrt3}{8}Bwa^2 s\theta = -\frac{\sqrt3}{24}Bwa^2 s\theta$

4.


(1) $4 \times Baw \times \frac{a}{2} = 2Bwa^2$　并联

(2) $r_{内} = \frac{\frac{1}{2}r\cdot\frac{1}{2}r}{\frac{1}{2}r+\frac{1}{2}r} = \frac{1}{4}r$

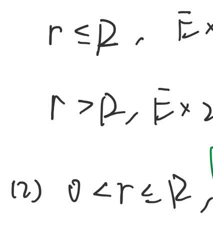
最大输出 $P \Rightarrow R = \frac{1}{4}r$

5.


(1) $\varepsilon = Blv$

(2) $E = \frac{\varepsilon}{d}$　$Eq = qvB$

(3) $\sigma = \varepsilon_0 E$

6.


$B = B_0(t)\,\hat z$

(1) $\varepsilon = \frac{d\Phi}{dt} = \frac{dB}{dt}\pi R^2$

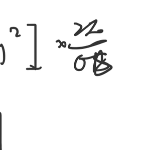
$\oint_C \vec E_{感}\cdot d\vec l = -\iint_S \frac{\partial B}{\partial t} dS$

$r \le R$，$E \times 2\pi r = -\frac{\partial B}{\partial t}\pi r^2$，$E_感 = -\frac{dB}{dt}\frac{\pi r^2}{2\pi r} = -\frac{r}{2}\frac{dB}{dt}$

$r > R$，$E \times 2\pi r = -\frac{\partial B}{\partial t}\pi R^2$，$E_感 = -\frac{dB}{dt}\frac{\pi R^2}{2\pi r} = -\frac{R^2}{2r}\frac{dB}{dt}$

(2) $0 < r \le R$，$j = \sigma E$，$j_1 = \frac{E_1}{\sigma} = \frac{\sigma r}{2}\frac{dB}{dt}$

$R < r < a$，$j_2 = \frac{E_2}{\sigma} = \frac{\sigma R^2}{2r}\frac{dB}{dt}$



(3) $P = I_1^2 R + I_2^2 R = I_1U_1 + I_2U_2$　$R = \rho\frac{L}{S} = \frac{L}{\sigma S}$

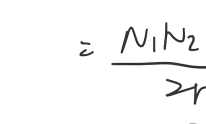
$= [(\int_0^R j_1 \delta\, dr)^2 + (\int_R^a j_2 \delta\, dr)^2] \times \frac{2\pi}{\sigma\delta}$　$= \frac{2\pi R}{\sigma R\delta}$

$= [(\int_0^R \frac{r\delta}{2\sigma}\frac{dB}{dt}dr)^2 + (\int_R^a \frac{R^2\delta}{2r\sigma}\frac{dB}{dt}dr)^2] \times \frac{2\pi}{\sigma\delta}$

$= (\frac{\delta\sigma}{2}\frac{dB}{dt})^2[(\int_0^R r\,dr)^2 + (\int_R^a \frac{R^2}{r}dr)^2] \times \frac{2\pi}{\sigma\delta}$

$= \frac{2\pi\delta^2\sigma}{8}(\frac{dB}{dt})^2[(\frac{1}{2}R^2)^2 + (R^2\ln\frac{a}{R})^2]$

$= \frac{\pi\delta\sigma}{2}(\frac{dB}{dt})^2R^4[\frac{1}{16} + (\ln\frac{a}{R})^2]$

7.(1)


$B_{12} = \int_0^{2\pi}\frac{\mu_0}{4\pi}\frac{I r_2 d\theta}{r_2^2} = \frac{N_2\mu_0 I}{2r_2}$

$\varepsilon_2 = \frac{d\Phi}{dt} = \frac{N_1 dB_{12}\pi r_1^2}{dt} = \frac{N_1\mu_0\pi r_1^2}{2r_2}\frac{dI}{dt}$

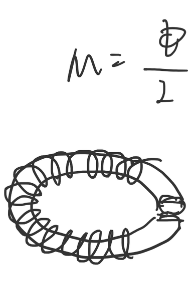
$= \frac{N_1N_2\mu_0\pi r_1^2}{2r_2}\frac{dI}{dt} = \frac{\mu_0}{2}\times\frac{0.09\pi}{0.5}\times 5\times10^{?}\times 5\times10^3$

(2) 小线圈 在 大线圈B中转动.

$\varepsilon = \frac{d\Phi}{dt} = \frac{N_1B_{12}dS}{dt} = \frac{N_1N_2\mu_0 I}{2r_2}\frac{d\,\pi r_1^2 c\theta}{dt}$

$= \frac{N_1N_2\mu_0 I r_1^2\pi s\theta\, w}{2r_2}$

$= \frac{5\times10^{?}\mu_0\times0.2\pi\times\frac{1}{2\times10^{?}\times60}\,s wt \times 0.09}{2\times0.5}$

8.


(1) 设 I　$B = \mu_0\frac{N}{2\pi r}I$

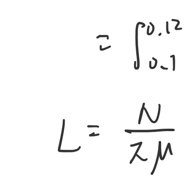
$\Phi = \int_R^{R+2a}\frac{\mu_0 NIh}{2\pi r}dr$　N　$2\pi rB = N\mu_0 I$

$= \frac{\mu_0 N^2 Ih}{2\pi}\ln\frac{R+2a}{R}$，$L = \frac{\mu_0 N^2 h}{2\pi}\ln\frac{R+2a}{R}$

(2) 线在立中的 $\Phi = \int_R^{R+2a}Bh\,dr = \int_R^{R+2a}\frac{\mu_0 I}{2\pi r}h\,dr$

$= \frac{N\mu_0 hI}{2\pi}\ln\frac{R+2a}{R}$

$M = \frac{\Phi}{I} = \frac{N\mu_0 h}{2\pi}\ln\frac{R+2a}{R}$

9.


(1) $NI = BS\frac{L}{\mu S} = \frac{BL}{\mu}$

$B = \frac{700\mu_0 NI}{L} = \frac{700\mu_0 1200\times1}{1\times10^{-3}} = 8.4\times10^{8}\mu_0 I$

(2) $H\times2\pi r = NI$，$B = \frac{NI}{2\pi r\mu}$　$S = 12 = 2r^2$，$r \approx 2a$

$\Phi = \int_{0.1}^{0.14}2\int_0^{\sqrt{4-(r-12)^2}}\frac{NIh}{2\pi r\mu}dh\,dr$

$= \int_{0.1}^{0.12}\int_0^{\sqrt{0.04-(0.12-r)^2}}\frac{NIh}{\pi r\mu}dh\,dr + \int_{0.12}^{0.14}\int_0^{\sqrt{0.04-(r-0.12)^2}}\cdots$

$L = \frac{N}{\pi\mu}[\int_{0.1}^{0.12}\int_0^{\sqrt{0.04-(0.12-r)^2}}\frac{h}{r}dh\,dr + \int_{0.12}^{0.14}\int_0^{\sqrt{0.04-(r-0.12)^2}}\frac{h}{r}dh\,dr]$

$\Phi_B(R_{m1}+R_{m2}) = NI$，$\Phi = \frac{\mu_0\mu_r SNI}{2\pi r+\mu_r d}$

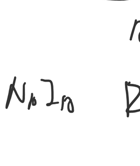
10.


(1) 设 I，$k = \frac{I}{l}$.　$B = \mu_0\frac{I}{l}$.

$B = \int_0^{2\pi}\int_0^{l}\frac{\mu_0}{4\pi}\frac{\frac{I}{l}R\,dl\,d\theta}{R^2} = \frac{\mu_0 I}{2R}$

$\Phi = BS = \frac{\mu_0 I}{2R}\times\pi R^2 l = \frac{\mu_0\pi IlR}{2}$

$L = \frac{\mu_0\pi lR}{2}$　$L = \frac{\mu_0\pi R^2}{l}$

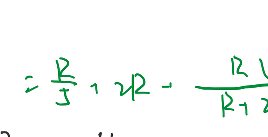
(2)


$E\times S = \frac{\sigma S}{\varepsilon_0}$，$E = \frac{\sigma}{\varepsilon_0}$

$Ed = U = \frac{\sigma d}{\varepsilon_0}$，$Q = \sigma S$

$C = \frac{Q}{U} = \frac{\sigma al}{\frac{\sigma d}{\varepsilon_0}} = \frac{\varepsilon_0 al}{d}$

(3) ……　$w_0 = \frac{1}{\sqrt{LC}}$

11.(1) AC.


$R = \frac{L}{\mu_r\mu_0 S}$

$N_A I_A$　$R_A = \frac{L_1}{\mu_r\mu_0 S_A} = \frac{R}{5}$　$R_B = \frac{L_1}{\mu_r\mu_0 S_B} = R$　$R_C = \frac{L_1}{\mu S_C} = 2R$

$N_A I_A = R_A + 2R + \frac{R_B(R_C+2R)}{R_B+R_C+2R}$

$= (\frac{L_1}{\mu S_A} + \frac{2L}{\mu S} + \frac{\frac{L_1}{\mu S_B}(\frac{2L}{\mu S}+\frac{L_1}{\mu S_C})}{\frac{L_1}{\mu S_B}+\frac{L_1}{\mu S_C}+\frac{2L}{\mu S}})\Phi$

$= \frac{R}{5} + 2R + \frac{R(4R)}{R+2R+2R} = 3R\cdot\Phi$

$M = \frac{\Phi}{I_A} = \frac{N_A}{3R} = \frac{N_A}{\frac{L}{\mu_r\mu_0 S}}$ ⇒ Φ 多.

$\Phi_B = \frac{R_3\Phi}{R_2+R_3}$，$\Phi_C = \frac{R_2\Phi}{R_2+R_3}$

$M_{AC} = \frac{N_C\Phi_C}{I_A}$　$M_{AB} = \frac{N_B\Phi_B}{I_A}$

(2)(1) $\varepsilon = \Phi(\frac{2\pi b}{\mu S} + \frac{w}{\mu_0 S}) = B\frac{2\pi b+w}{\mu}$　N 匝，$N\times2\pi a = l$.

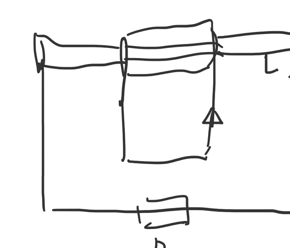
$R = \rho\frac{2\pi aN}{\pi r^2} = \frac{2\rho aN}{r^2}$　$I = \frac{V}{R}$，$\varepsilon = NI = \frac{NV}{\frac{2\rho aN}{r^2}} = \frac{Vr^2}{2\rho a}$

$B = \frac{\frac{Vr^2}{2\rho a}}{\frac{2\pi b+w}{\mu}} = \frac{Vr^2\mu}{2\rho a(2\pi b+w)}$

(2) $P = IU = \frac{V^2}{R} = \frac{V^2r^2}{2\rho aN}$

(3) I 与 rc → L，$T = NB\pi a^2$，$L = \frac{T}{I}$.

$I = \frac{L}{R} = $ ____ ?

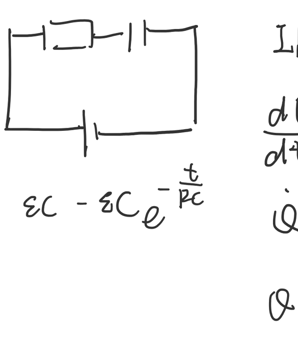
14.


环路定理 $B\times L = nLI$

$B = \mu_0 nI = \mu_0\frac{N}{l}I$.

$\Phi = NBS = \mu_0\frac{N^2}{l}IS$.　$\Phi = N'BS = \mu_0\frac{N'N}{l}IS$

$L = \frac{\Phi}{I} = \mu_0\frac{N^2}{l}S$　$M = \mu_0\frac{N'N}{l}S$.



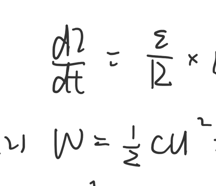
$I = 1A$.

$\Phi = MI = \mu_0\frac{N'N}{l}SI$.

$iR + L\frac{di}{dt} = 0$　$IR + L\frac{dI}{dt} + M\frac{dI'}{dt} = 0$

$qR = -L\Delta i$.　$Q = \frac{M\Delta I'}{R}$.

不是全闭合的.

16.


$IR + \frac{1}{C}\int I\,dt = \varepsilon$.

$\frac{dQ}{dt}R + \frac{1}{C}Q = \varepsilon$.　特. $Q = \varepsilon C$

$\dot Q + \frac{Q}{CR} = \frac{\varepsilon}{R}$.　通. $\frac{dQ}{dt} = -\frac{1}{CR}Q$

$\varepsilon C - \varepsilon Ce^{-\frac{t}{RC}}$

$Q = \varepsilon C(1 - e^{-\frac{t}{RC}})$　$\frac{1}{Q}dQ = -\frac{1}{CR}dt$

$\ln Q = -\frac{1}{CR}t$

$Q = e^{-\frac{1}{CR}t}$.

(1) $\frac{dQ}{dt} = I = -\varepsilon C\times(-\frac{1}{RC})e^{-\frac{t}{RC}} = \frac{\varepsilon}{R}e^{-\frac{t}{RC}}$.

$\frac{dI}{dt} = \frac{\varepsilon}{R}\times(-\frac{1}{RC})e^{-\frac{t}{RC}} = -\frac{\varepsilon}{R^2C}e^{-\frac{t}{RC}}$

(2) $W = \frac{1}{2}CU^2 = \frac{Q^2}{2C}$

$\frac{dQ^2}{dt} = \varepsilon^2C^2\times2(1-e^{-\frac{t}{RC}})\times\frac{1}{RC} = \frac{2\varepsilon^2C}{R}(1-e^{-\frac{t}{RC}})\ (\times\frac{1}{2C})$

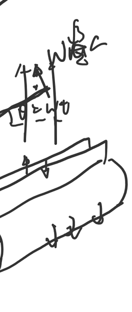
$\frac{d}{dt}(\frac{dW}{dt}) = \frac{\varepsilon^2}{R}\times\frac{1}{RC}\times e^{-\frac{t}{RC}}$

(3) $P = I^2R$.

$\frac{dP}{dt} = R\times2I\frac{dI}{dt} = R\times\frac{2\varepsilon}{R}e^{-\frac{t}{RC}}\times(-\frac{\varepsilon}{R^2C})e^{-\frac{t}{RC}}$

$= -\frac{2\varepsilon^2}{R^2C}e^{-\frac{2t}{RC}}$.

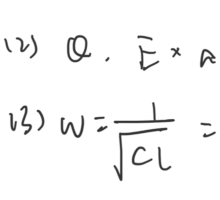
(4) $P = I\varepsilon$.　$\frac{dP}{dt} = \varepsilon\frac{dI}{dt} = -\frac{\varepsilon^2}{R^2C}e^{-\frac{t}{RC}}$

3.


AC：$\varepsilon = B\times\frac{\sqrt3}{2}a\,w\times\frac{\sqrt3}{4}a = \frac{3}{8}Bwa^2$

$\varepsilon = \int_A^C(\vec v\times\vec B)\cdot d\vec l$

$= \int_0^a\frac{\sqrt3 wlB s\theta}{2}\times\frac{1}{2}dl = \frac{\sqrt3}{8}Bwa^2 c\theta$.

12.


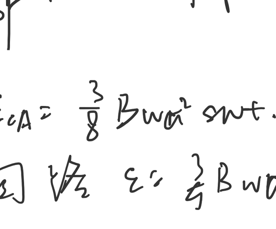
$\mu_0 j = \mu_0\frac{I}{l}$

(1) $B = \frac{\mu_0 Il}{2R}$　$\Phi = \frac{\mu_0 Il\pi R^2}{2R} = \mu_0\frac{I l\pi R}{2}$

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

(2) Q，$E\times al = \frac{Q}{\varepsilon_0}$，$E = \frac{Q}{\varepsilon_0 al}$．$U = \frac{Qd}{\varepsilon_0 al}$．$C = \frac{\varepsilon_0 al}{d}$.

(3) $w = \frac{1}{\sqrt{CL}} = \frac{1}{\sqrt{\frac{\mu_0 l\pi R}{2}\times\frac{\varepsilon_0 al}{d}}} = \sqrt{\frac{2d}{\mu_0\varepsilon_0 l^2\pi aR}}$

3.


$\varepsilon = Blv$

$= B\int_0^{\frac{\sqrt3}{2}a}wr\,dr$

$= Bw\cdot\frac{1}{2}r^2\Big|_0^{\frac{\sqrt3}{2}a} = \frac{3}{8}Bwr^2 swt$.

[注意一下. $v = \frac{\sqrt3}{2}wl$.

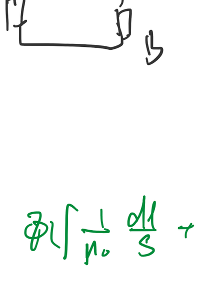
积分 $\int_0^a\frac{\sqrt3}{2}wlB\,s\theta\times\cos60°$

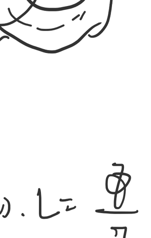
$\varepsilon_{CA} = \frac{3}{8}Bwa^2 swt = \varepsilon_{BC}$.

回路 $\varepsilon = \frac{3}{4}Bwa^2 swt$.

$I = \frac{\varepsilon}{R} = \frac{1}{4}Bwa^2 swt$

$U_{BA} = I\frac{R}{3} = \frac{1}{12}Bwa^2 swt$.



9.


$H\times2\pi R = NI$

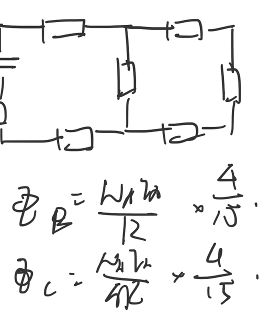
$\frac{B_0}{\mu_0} + \frac{B}{\mu_r\mu_0} = \frac{NI}{2\pi R}$

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

则 $(\int\frac{1}{\mu_0}\frac{dl}{S} + \frac{1}{\mu_r\mu_0}\frac{dl}{S}) = NI$

$\frac{B}{\mu_0\mu_r}2\pi r + \frac{B}{\mu_0}d = NI$.

(2) $L = \frac{\Phi}{I} = \frac{NBS}{I} = \frac{\mu_0 N^2 S}{\frac{2\pi r}{\mu_r}+d}$

11.


$R = \frac{1}{\mu_r\mu_0}\frac{L}{S}$

$R_A = \frac{1}{\mu_r\mu_0}\frac{L_1}{S_1}$　$R_B = \frac{1}{\mu_r\mu_0}\frac{L_2}{S_2}$

$\Phi_B = \frac{N_A I_A}{R}\times\frac{4}{15}$　$M = \frac{N_B\Phi_B}{I_A}$

$\Phi_C = \frac{N_A I_A}{4R}\times\frac{4}{15}$　$M = \frac{N_C\Phi_C}{I_A}$