Chapter 8

8-1

解:

由电磁感应定律，得:

$$\mathscr{E} = -\frac{d\Phi}{dt} = -\pi a^2 \frac{dB}{dt} = -\pi(3t+4) \times 10^{-6} \qquad \text{(SI)}$$

又由欧姆定律，得:

$$I = \frac{\mathscr{E}}{R}$$

- (1) 代入$t = 2s$，得:

$$\mathscr{E} = -3.14 \times 10^{-5}\ \mathrm{T}$$
$$I = -3.14 \times 10^{-2}\ \mathrm{A}$$

- (2)

$$Q = |\frac{\Delta\Phi}{R}| = 4.4 \times 10^{-2}\ \mathrm{C}$$

8-2

解:

- (1)
  由电磁感应定律，得:

$$\begin{aligned}\mathscr{E} = \int_L (\boldsymbol{v} \times \boldsymbol{B}) \cdot d\boldsymbol{l} &= \frac{\mu_0 I v}{2\pi} \cot\theta \int_d^{d+l\sin\theta} \frac{dr}{r} \\ &= \frac{\mu_0 I v}{2\pi} \cot\theta \ln\frac{d+l\sin\theta}{d} \\ &= 2.79 \times 10^{-4}\ \mathrm{V}\end{aligned}$$

- (2)
  由$\mathscr{E} > 0$，得D电势高。

8-4

解：

$$U_{ab} = \mathscr{E} = \int_L (\boldsymbol{\omega} \times \boldsymbol{r} \times \boldsymbol{B}) \cdot d\boldsymbol{l} = -\frac{B\omega l^2}{4}$$

由于$U_{ab} < 0$，故b点电势高

8-6

解：

- (1)
  对棒及电路进行分析，可得：

$$\begin{aligned} \mathscr{E} &= Blv \\ I &= \frac{\mathscr{E}}{R} \\ m\frac{dv}{dt} &= -BIl \end{aligned}$$

  联立得：

$$\begin{aligned} &\frac{dv}{dt} + \frac{B^2 l^2}{mR} v = 0 \\ \Rightarrow &v = v_0 e^{-\frac{t}{\tau}} \qquad\qquad (\text{其中}\tau = \frac{mR}{B^2 l^2}) \end{aligned}$$

- (2)

$$\begin{aligned} &\frac{dv}{dt} + \frac{B^2 l^2}{mR} v = 0 \\ \Rightarrow &v\frac{dv}{dx} + \frac{v}{\tau} = 0 \\ \Rightarrow &\frac{dv}{dx} = -\frac{1}{\tau} \\ \Rightarrow &x = -\tau(v - v_0) \end{aligned}$$

停止运动时，$v=0$，得:

$$x_m=\frac{mRv_0}{B^2l^2}$$

- (3)

$$Q=\int_0^t I^2Rdt=\frac{B^2l^2}{R}\int_0^t v^2dt$$

代入$v=v_0(1-e^{-\frac{t}{\tau}})$，令$t\to+\infty$，得:

$$Q=\frac{1}{2}mv_0^2$$

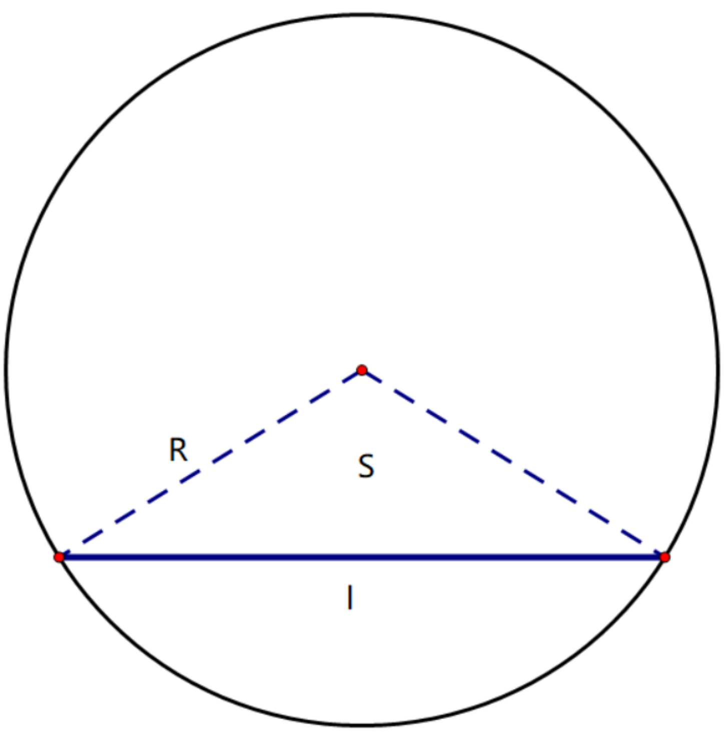
- (4) 由能量守恒，应有:

$$Q=-\Delta E_k$$

上述结果满足此式。

8-9

解:



如图，有圆形磁场区域感生电场垂直于半径，所以两虚线上无感应电动势。故:

$$U_{PQ}=-\frac{d\Phi}{dt}=-\frac{l}{4}\sqrt{4R^2-l^2}\frac{dB}{dt}$$

负号表示Q电势更高。

8-10

解:

- (1)

$$\Phi = \int_a^b -\frac{\mu_0}{2\pi}\frac{I}{r}ldr = -\frac{\mu_0 l}{2\pi}\ln\frac{b}{a}I_0e^{-ct}$$

 由电磁感应定律，得:

$$\mathscr{E} = -\frac{d\Phi}{dt} = -\frac{\mu_0 lc}{2\pi}\ln\frac{b}{a}I_0e^{-ct}$$

 电流为逆时针方向。
- (2)

$$M = \frac{\Phi}{I} = \frac{\mu_0 l}{2\pi}\ln\frac{b}{a}$$

8-11

解:

由8-10的结论，得互感系数:

$$M = \frac{\mu_0 c}{2\pi}\ln\frac{b}{a}$$

故有:

$$\mathscr{E} = -M\frac{di}{dt} = -\frac{\mu_0 cI_0\omega}{2\pi}\cos\omega t\ln\frac{b}{a}$$

8-14

解:

对于中间部分，即距离某导线距离为r到$d-r$，长度为l的一部分，磁通量为:

$$\Phi = 2\int_{r}^{d-r} \frac{\mu_0}{2\pi}\frac{I}{r} l dr = \frac{\mu_0 I l}{\pi}\ln\frac{d-r}{r}$$

故有:

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

8-15

解:

答案为D.