Homework4

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P4-1:

a)

容易见得, N匝线圈在磁场中总的磁通量满足:

$$\Phi(\theta) = NabB\cos(\theta)$$

有 $\theta = \omega t = 2\pi f t$

$$\Phi(t) = NabB\cos(2\pi ft)$$

因而由法拉第电磁感应定律得到:

$$\mathscr{E} = -rac{\partial \Phi}{\partial t} = 2\pi f Nab B \sin(2\pi f t) = \mathscr{E}_0 \sin(2\pi f t)$$

其中 $\mathscr{E}_0 = 2\pi f NabB$

b)

$$Nab = rac{\mathscr{E}_0}{2\pi fB} = rac{150}{2\pi \cdot 60.0 \cdot 0.500} m^2 = 0.80 m^2$$

P4-2:

a)

由对称性容易知道,在线圈上面部分的磁通量正反相互抵消,只有线圈下方2a-b长度的距离磁通量不为0

$$\Phi(t) = \int_{b-a}^a rac{\mu_0}{2\pi} rac{i(t)}{r} dr = rac{\mu_0}{2\pi} \mathrm{ln} \, rac{a}{b-a} i(t) = rac{4\pi imes 10^{-7}}{2\pi} \mathrm{ln} \, 4 \cdot (4.50t^2 - 10.0t) T \cdot m^2$$

因而

$$\mathscr{E}(t) = -rac{\partial \Phi(t)}{\partial t} = 4 \ln 2(9t-10) imes 10^{-7} V$$

代入t = 3.0s容易得到

$$\mathcal{E}(3.0)=4.7\times 10^{-6}V$$

b)

根据右手螺旋定则不难判断t=3.0s时刻磁通量的方向垂直纸面向里且在增大,因而产生的感应电动势的方向应该为逆时针方向。

P4-3

a)

$$S = L(s_0 + vt)$$
 $\Phi(t) = \int_a^{a+L} rac{\mu_0}{2\pi} rac{I}{r} \cdot L(s_0 + vt) dr = rac{\mu_0 IL}{2\pi} \ln rac{a+L}{a} (s_0 + vt)$ $\mathscr{E} = -rac{\partial \Phi(t)}{\partial t} = rac{\mu_0 IL}{2\pi} \ln rac{a+L}{a} v =$

b)

$$i=\mathscr{E}/R=rac{\mu_0IL}{2\pi R} ext{ln}\,rac{a+L}{a}v=$$

方向沿顺时针方向

c)

$$P_{thermal} = i^2 R =$$

d)

$$F = \int_a^{a+L} rac{\mu_0}{2\pi} rac{I}{r} \cdot i \cdot dr = rac{\mu_0 Ii}{2\pi} ext{ln} \, rac{a+L}{a}$$

e)

$$P=Fv=rac{\mu_0 Ii}{2\pi} {
m ln}\,rac{a+L}{a} v$$

P4-4

P4-5

a)

由安培环路定理知道:

$$egin{aligned} \mathscr{E} &= iR + Lrac{di}{dt} \Rightarrow rac{\mathscr{E} - iR}{L}dt = di \ \\ &\Rightarrow rac{L}{\mathscr{E} - iR}di = dt \Rightarrow rac{L/R}{\mathscr{E}/R - i}di = dt \end{aligned}$$

因而有

$$egin{aligned} t = rac{L}{R} \mathrm{ln} \, rac{\mathscr{E}/R}{\mathscr{E}/R - i} \ & \ rac{\mathscr{E}/R}{\mathscr{E}/R - i} = e^{rac{R}{L}t} \Rightarrow i = rac{\mathscr{E}}{R} (1 - e^{-rac{R}{L}t}) \end{aligned}$$

所以由电池传送的能量

$$E_{battery} = q\mathscr{E} = \mathscr{E} \int_0^t rac{\mathscr{E}}{R} (1 - e^{-rac{R}{L}t}) dt =$$

b)

$$E_L = \frac{1}{2} L i^2 =$$

c)

$$Q=\int_0^t i_{(t)}^2 r dt=$$

其实上面的能量也可以由能量守恒式得到