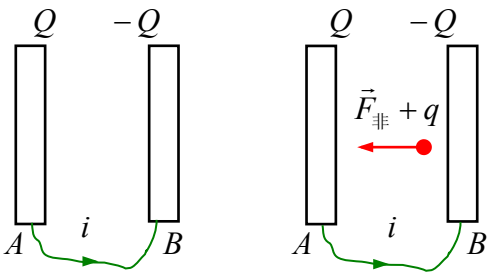
12—1 法拉第定律

一、电动势



如何在导线中维持一个持续不断的电流？
能够提供非静电力的装置：电源
把其它形式的能量转化为电能的装置

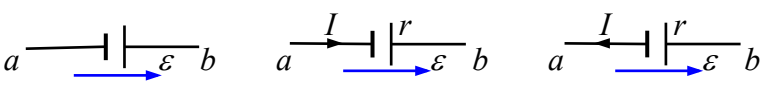
电动势：$\varepsilon = \dfrac{A_{非}}{q}$，$A_{非} = \int_{(-)内}^{(+)} \vec{F}_{非} \cdot d\vec{l}$

$$\varepsilon = \frac{1}{q}\int_{(-)内}^{(+)} \vec{F}_{非} \cdot d\vec{l} = \int_{(-)内}^{(+)} \frac{\vec{F}_{非}}{q} \cdot d\vec{l}$$

$\dfrac{\vec{F}_{非}}{q} = \vec{E}_{非}$：非静电场强

$$\varepsilon = \int_{(-)内}^{(+)} \vec{E}_{非} \cdot d\vec{l}$$

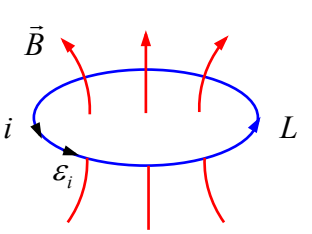
电动势：标量，SI：J/C=V，正方向：负极 $\xrightarrow{内部}$ 正极



$U_{ab} = -\varepsilon$　　$U_{ab} = -\varepsilon + Ir$　　$U_{ab} = -\varepsilon - Ir$

$$\boxed{\varepsilon = \oint_L \vec{E}_{非} \cdot d\vec{l}}$$

二、法拉第电磁感应定律

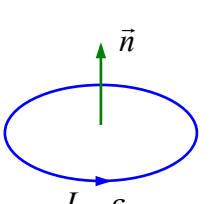


1831 年
电磁感应
感应电流
感应电动势

$\varepsilon_i \propto \dfrac{d\Phi_m}{dt}$，$\varepsilon_i = -k\dfrac{d\Phi_m}{dt}$

SI：ε_i：V，Φ_m：Wb，t：s，$k=1$

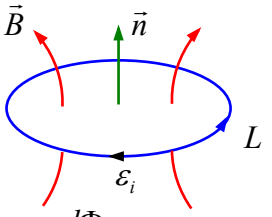
$$\boxed{\varepsilon_i = -\frac{d\Phi_m}{dt}}$$



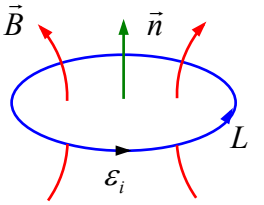
$$\Phi_m = \int_S \vec{B} \cdot d\vec{S}$$

回路绕行正方向：
感应电动势的正方向

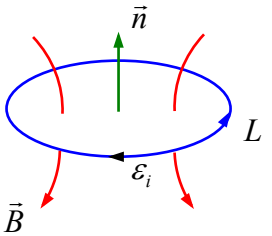
讨论：



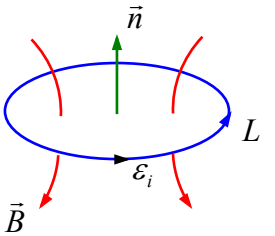
$\Phi_m > 0$，**if** $\dfrac{d\Phi_m}{dt} > 0$， $\varepsilon_i < 0$



$\Phi_m > 0$，**if** $\dfrac{d\Phi_m}{dt} < 0$， $\varepsilon_i > 0$



$\Phi_m < 0$，**if** $\dfrac{d\Phi_m}{dt} > 0$， $\varepsilon_i < 0$



$\Phi_m < 0$，**if** $\dfrac{d\Phi_m}{dt} < 0$， $\varepsilon_i > 0$

注意：（1）列电压方程时用电动势的正方向

（2）ε_i 的大小与正负由 $\dfrac{d\Phi_m}{dt}$ 决定

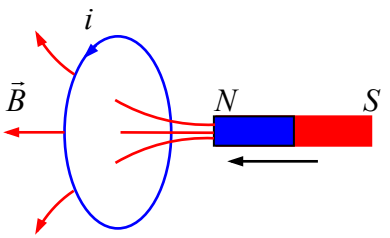
（3）N 匝线圈串联，$\varepsilon_i = -N\dfrac{d\Phi_m}{dt} = -\dfrac{d}{dt}(N\Phi_m)$

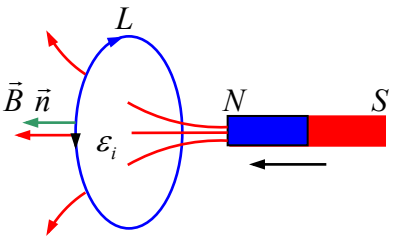
$N\Phi_m = \psi_m$：全磁通或磁链

三、楞次定律

闭合回路中，感应电流的实际方向总是使得它自身产生的磁场阻碍原来磁通量的变化

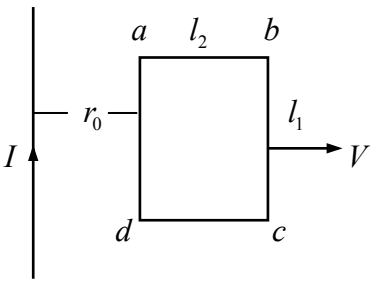
例：





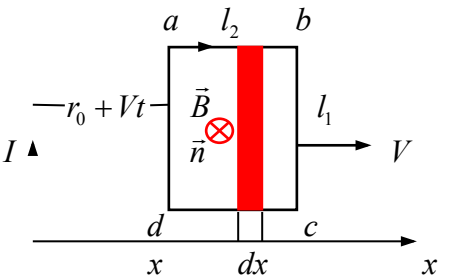
$\Phi_m > 0$， $\dfrac{d\Phi_m}{dt} > 0$， $\varepsilon_i < 0$

例：



求：任意时刻线圈中的 ε_i

解：



取回路正方向：顺时针

$$\Phi_m=\int_S \vec{B}\cdot d\vec{S}=\int_S B\cos\theta dS$$

$$=\int_{r_0+Vt}^{r_0+Vt+l_2}\frac{\mu_0 I}{2\pi x}l_1 dx=\frac{\mu_0 I l_1}{2\pi}\ln\frac{r_0+Vt+l_2}{r_0+Vt}$$

$$\varepsilon_i=-\frac{d\Phi_m}{dt}=-\frac{\mu_0 I l_1}{2\pi}\left(\frac{V}{r_0+Vt+l_2}-\frac{V}{r_0+Vt}\right)$$

$$=\frac{\mu_0 I l_1 V l_2}{2\pi(r_0+Vt+l_2)(r_0+Vt)}>0$$，顺时针

磁通量变化方式：

（1）磁场随时间变化，回路不动：感生电动势

（2）磁场恒定不变，　回路或其一部分运动：动生电动势

（3） 磁场随时间变化，回路或其一部分运动