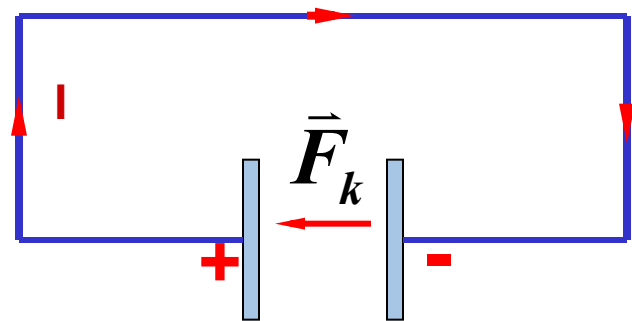


◆ 1 电动势

$$\mathcal{E} = \frac{A_K}{q}$$



$$\mathcal{E} = \int_{-}^{+} \vec{E}_k \cdot d\vec{l}$$

$\vec{E}_k$: 非静电的电场强度.

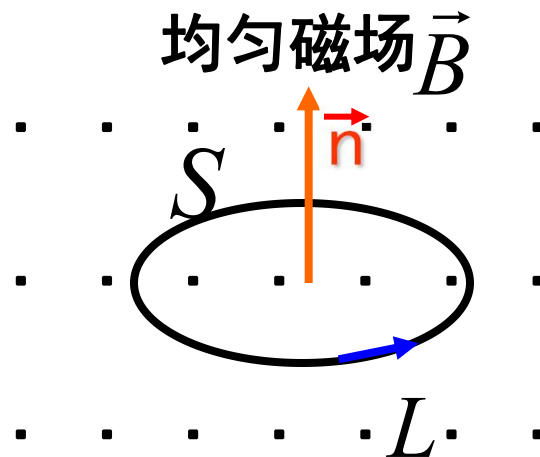
◆ 闭合电路的总电动势

$$\mathcal{E} = \oint_l \vec{E}_k \cdot d\vec{l}$$

◆ 感应电动势的方向

描述： 感应电动势的大小和通过导体回路的磁通量的变化率成正比。

$$\mathcal{E}_i = - \frac{d\Phi}{dt}$$



✂ 首先任定回路的绕行方向

据右手螺旋确定回路包围面积的法线方向

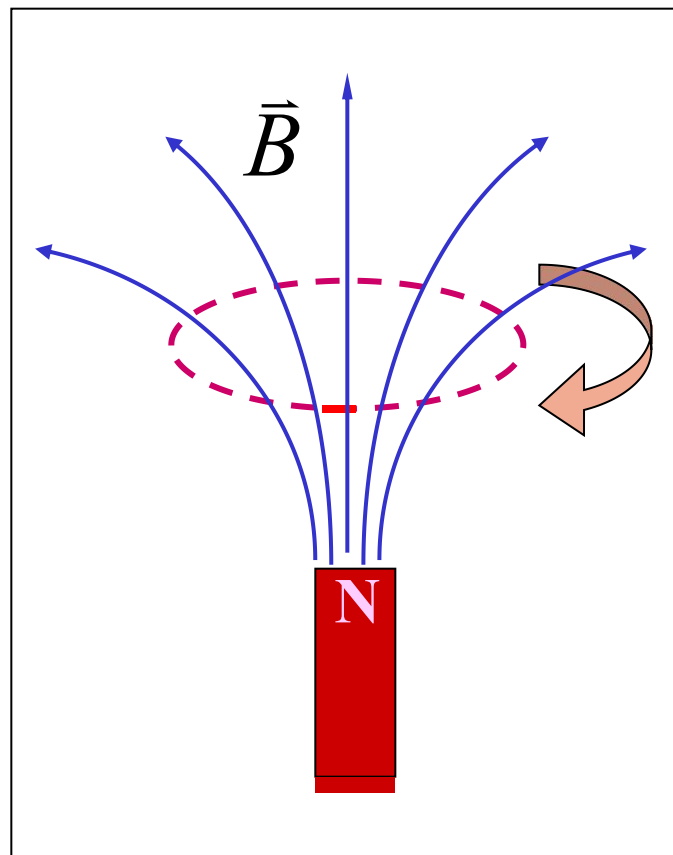
据确定磁通量的正负 ($d\Phi = \vec{B} \cdot d\vec{S}$)

确定电动势的正负：若 $\mathcal{E} > 0$, 电动势方向与绕行方向一致；

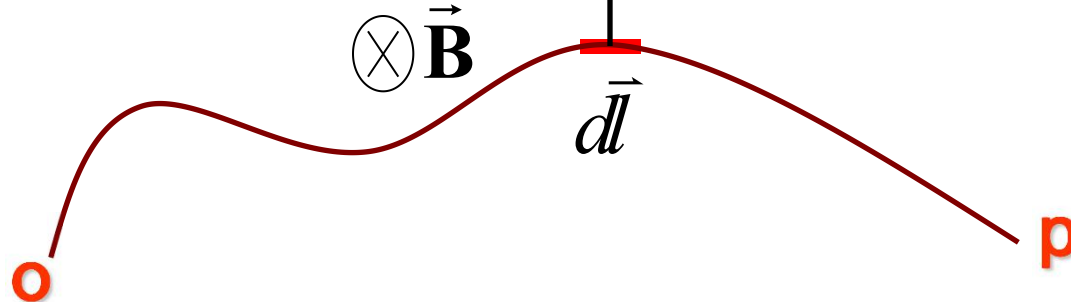
若 $\mathcal{E} < 0$, 电动势方向与绕行方向相反

楞次定律

闭合的导线回路中所出现的**感应电流**，总是使它自身的**磁通量反抗原磁通的变化**（反抗相对运动、磁场变化或线圈变形等）。



动生电动势

$$\varepsilon_i = \int d\varepsilon_i = \int_L (\vec{v} \times \vec{B}) \cdot d\vec{l}$$


The diagram shows a curved wire segment connecting point O (left) to point P (right). A magnetic field vector $\vec{B}$ is represented by a circle with an 'X' inside, indicating it points into the page. An upward-pointing arrow labeled $\vec{v}$ indicates the velocity of the wire. A small red segment on the wire is labeled $d\vec{l}$.

若 $\varepsilon_i > 0$, 动生电动势 ε_i 与 $d\vec{l}$ 方向相同,
从 O 指向 P , P 点为高电势点

若 $\varepsilon_i < 0$, 动生电动势 ε_i 与 $d\vec{l}$ 方向相反,
从 P 指向 O , O 点为高电势点

感生电动势：

(1) 导体回路： $\oint \vec{E}_i \cdot d\vec{l} = - \int_S \frac{\partial \vec{B}}{\partial t} \cdot d\vec{S}$

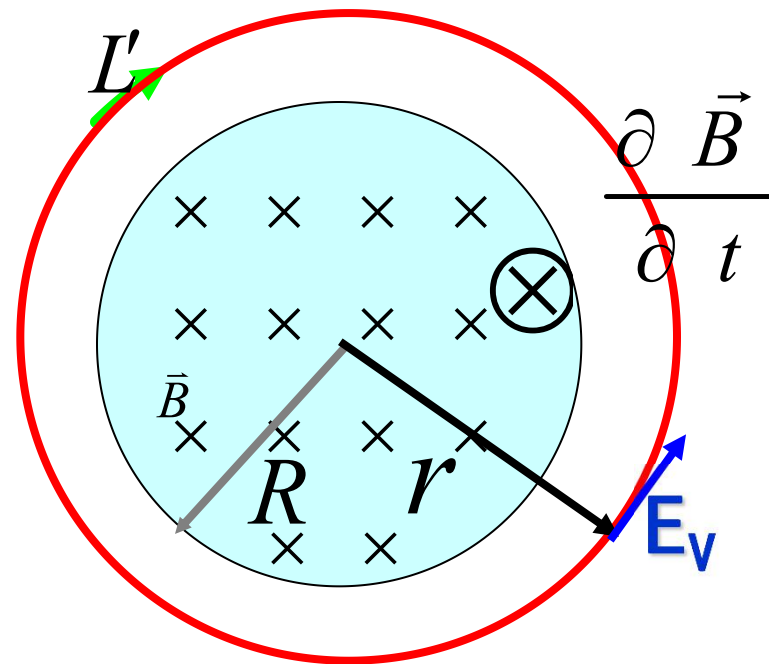
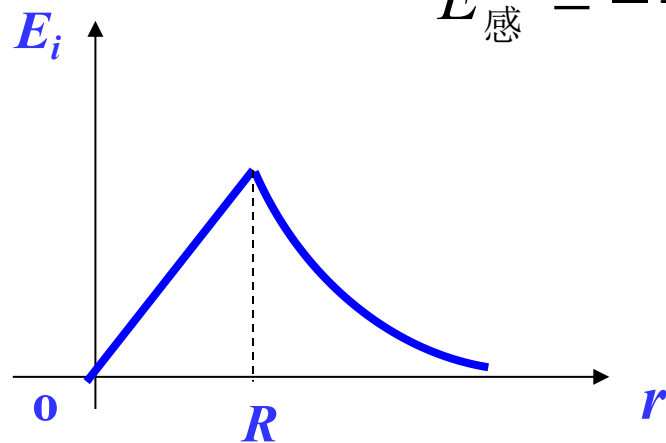
一段导体： $\int_L \vec{E}_i \cdot d\vec{l}$

$r < R$ 时,

$$E_{\text{感}} = -\frac{r}{2} \frac{\partial B}{\partial t}$$

$r > R$ 时

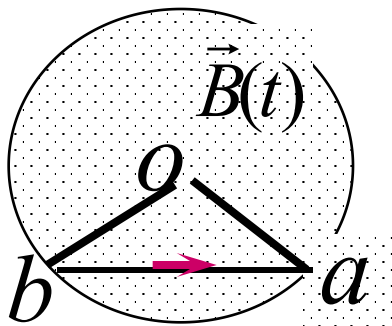
$$E_{\text{感}} = -\frac{R^2}{2r} \frac{\partial B}{\partial t}$$



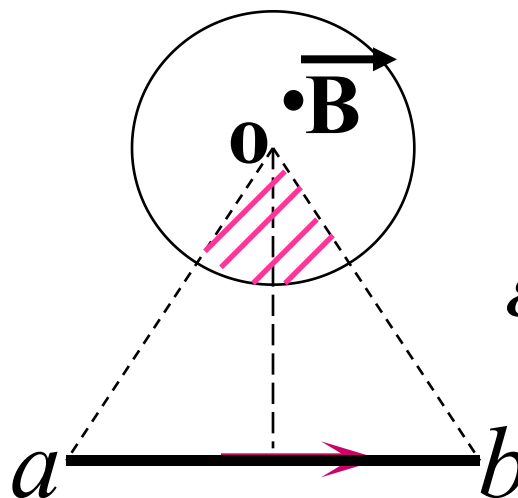
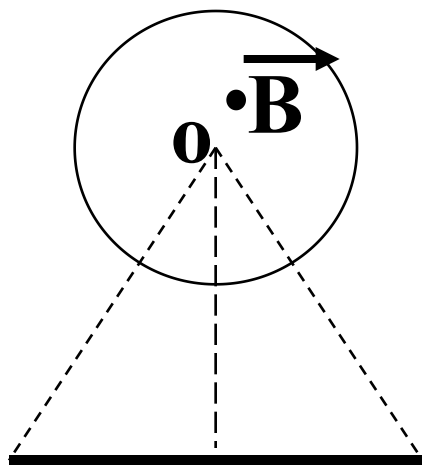
若 $\frac{\partial B}{\partial t} < 0$,

则 $E_i > 0$, 沿顺时针走向。

重要结论： 半径 oa 线上的感生电动势为零



$$\mathcal{E}_{ba} = -S_{\Delta} \frac{dB}{dt}$$



$$\mathcal{E}_{ab} = -S_{\text{扇形}} \frac{dB}{dt}$$

自感的计算方法

$$\text{设电流 } I \rightarrow \mathbf{B} \rightarrow \Phi \rightarrow \psi \rightarrow L = \frac{\psi}{I}$$

▪

互感的计算方法

$$\text{设电流 } I_1 \rightarrow \mathbf{B}_2 \rightarrow \Phi_{21} \rightarrow \psi_{21} \rightarrow M = \frac{\psi_{21}}{I}$$

$$\text{设电流 } I_2 \rightarrow \mathbf{B}_1 \rightarrow \Phi_{12} \rightarrow \psi_{12} \rightarrow M = \frac{\psi_{12}}{I_2}$$

◆ 磁场能量密度

$$w_m = \frac{B^2}{2\mu} = \frac{1}{2} \mu H^2 = \frac{1}{2} BH$$

◆ 磁场能量

$$W_m = \int_V w_m dV = \int_V \frac{B^2}{2\mu} dV$$



位移电流

$$I_d = \int_S \vec{j}_d \cdot d\vec{s} = \int_S \frac{\partial \vec{D}}{\partial t} \cdot d\vec{s} = \frac{d\Psi}{dt}$$

$$\vec{D} = \varepsilon_r \varepsilon_0 \vec{E}$$

麦克斯韦方程组

(1) 电场的高斯定理 $\oint_S \vec{D} \cdot d\vec{S} = \sum_i q_i$

(2) 法拉弟电磁感应定律

$$\oint_L \vec{E} \cdot d\vec{l} = -\frac{d\Phi_m}{dt} = -\int_S \frac{\partial \vec{B}}{\partial t} \cdot d\vec{S}$$

(3) 磁场的高斯定理 $\oint_S \vec{B} \cdot d\vec{S} = 0$

(4) 全电路安培环路定理

$$\oint_L \vec{H} \cdot d\vec{l} = \sum I_i + \frac{d\Phi_D}{dt} = \sum I_i + \int_S \frac{\partial \vec{D}}{\partial t} \cdot d\vec{S}$$