



云南省职工业务技能大赛——

“高教社杯” 高等师范院校

物理学教师教学技能大赛决赛





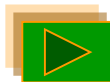
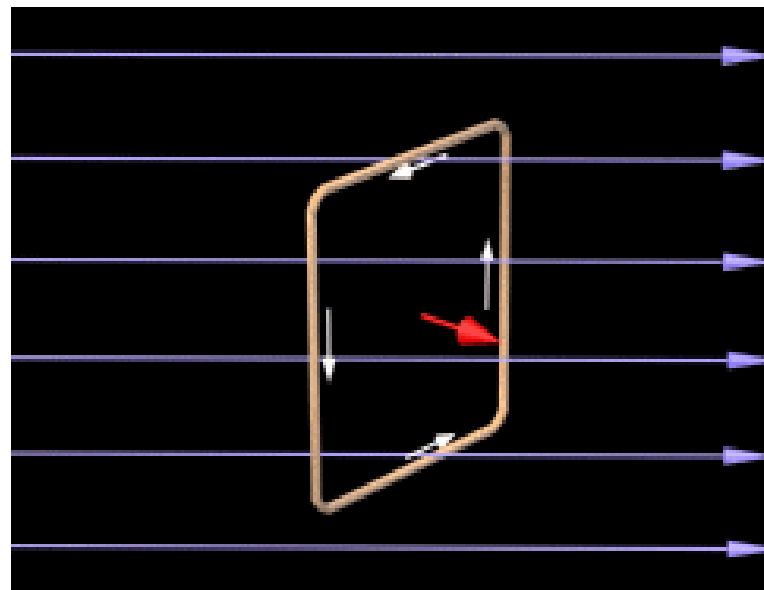
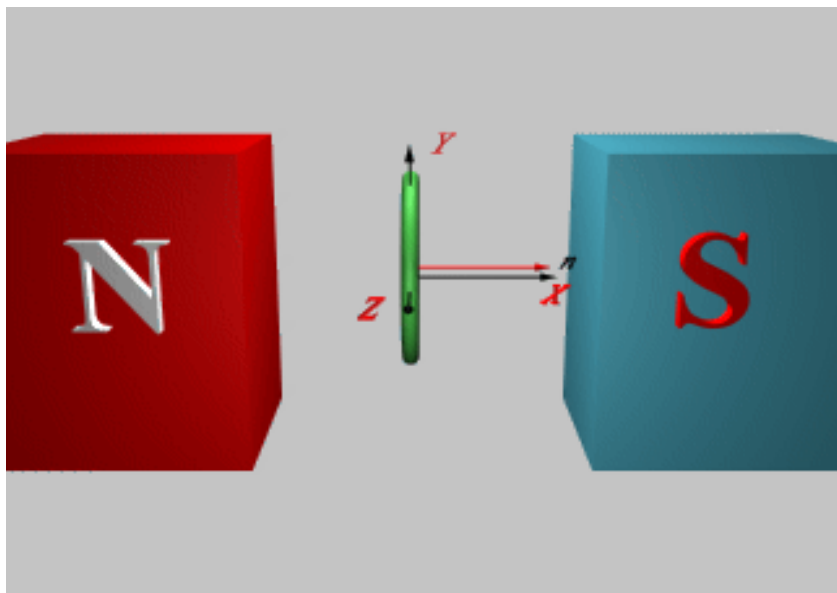
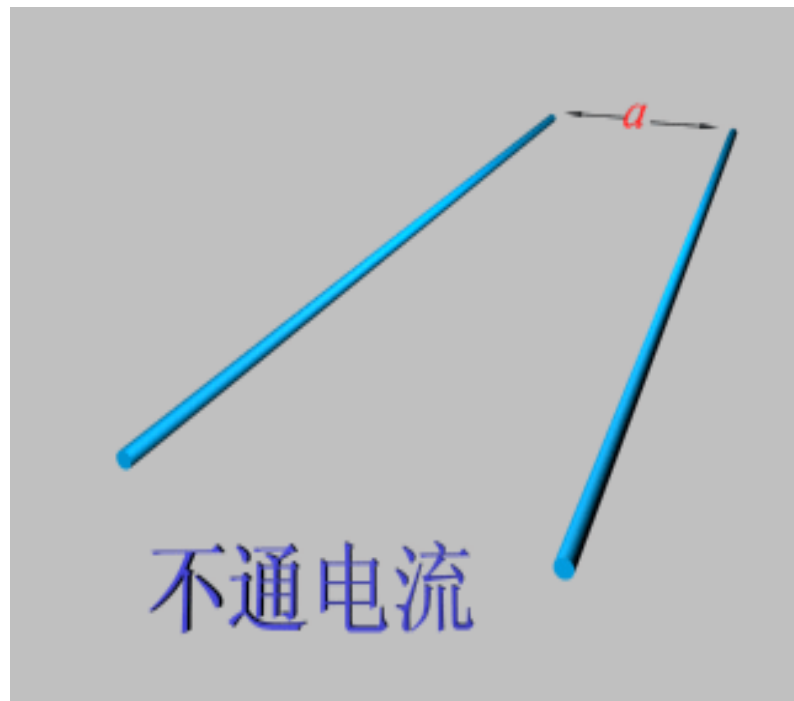
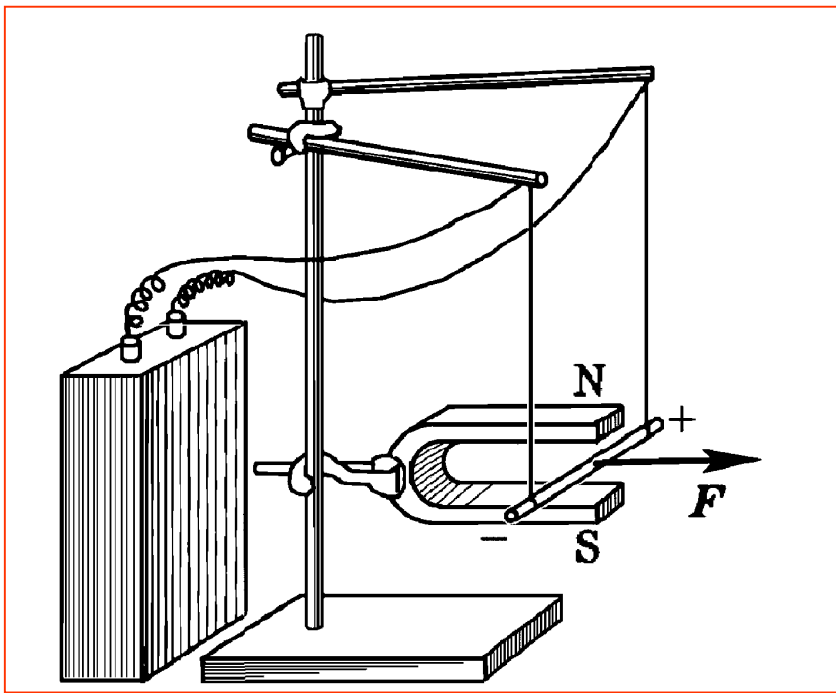
问题一、 已知电流分布，求磁场的分布？

方法一：
$$\vec{B} = \frac{\mu_0}{4\pi} \oint_L \frac{Id\vec{l} \times \vec{e}_r}{r^2}$$

方法二：
$$\oint_L \vec{B} \cdot d\vec{l} = \mu_0 \sum_{(l内)} I_i \quad (\text{对称性})$$

问题二、 已知磁场分布，求对电流的作用力？

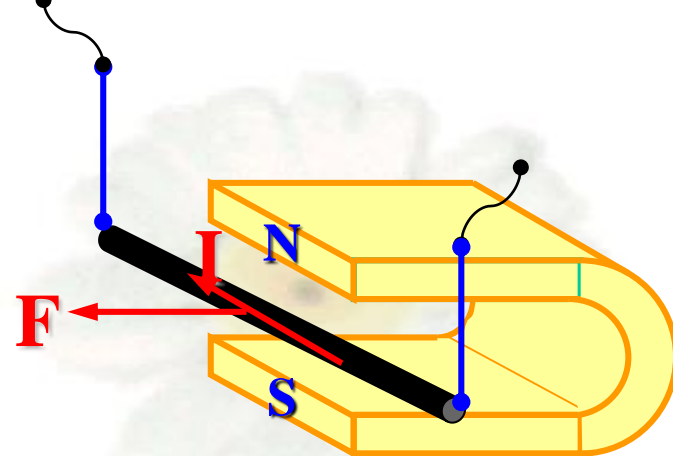




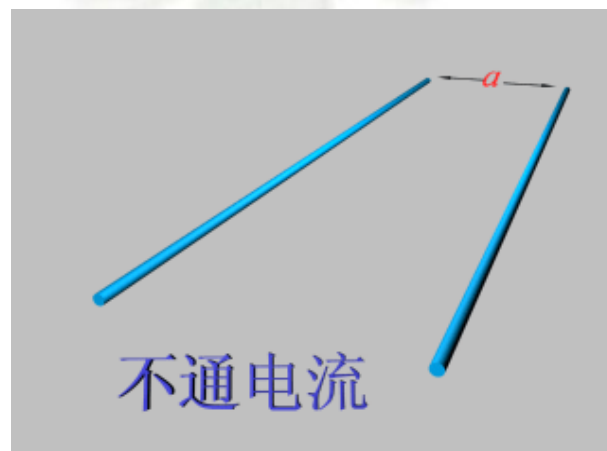
§ 5-6 磁场对载流导线的作用



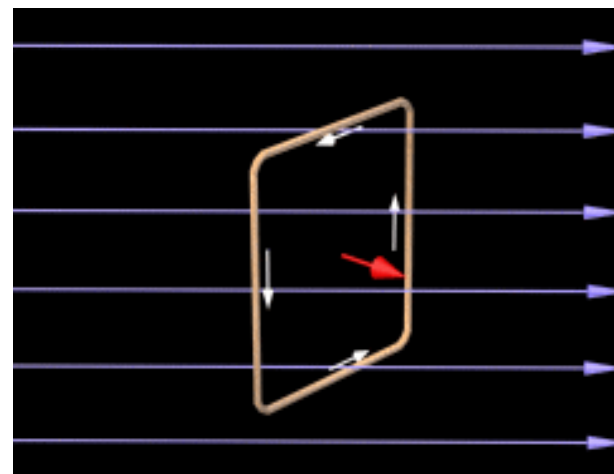
磁场对任意载流导线的作用



平行无限长电流间的相互作用

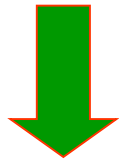


载流线圈在匀强磁场所受的力矩



磁场对任意载流导线的作用

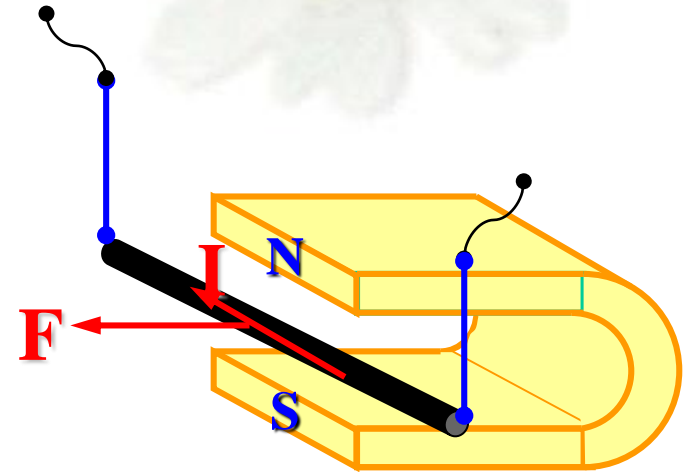
提出问题



安培定律



计算任意载流导线所受的作用力



提出问题:



如何求任意载流导线在磁场中所受的作用力?

方法:

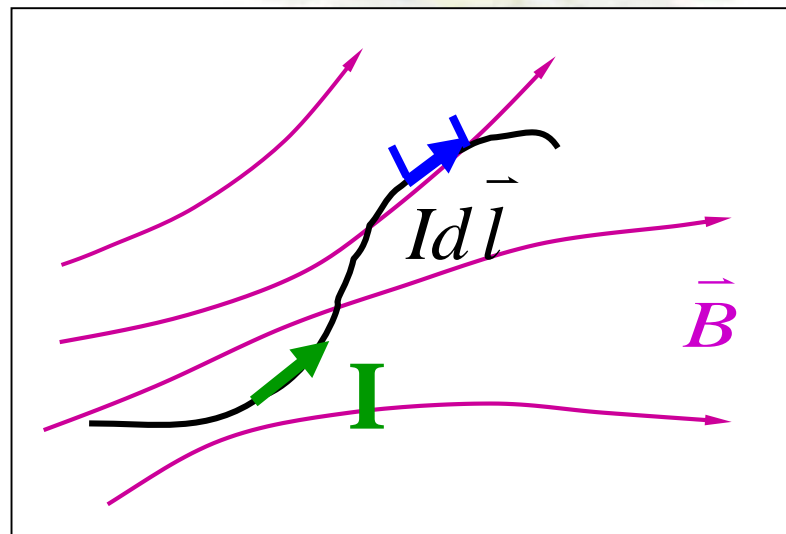
任选 $Id\vec{l}$



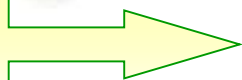
求出 $d\vec{F}$



$$\vec{F} = \int d\vec{F}$$



安培定律

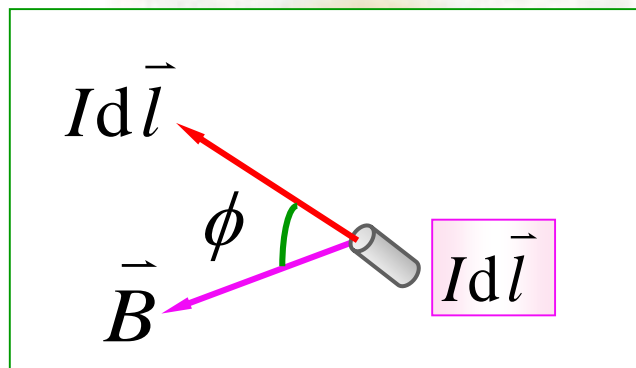


$$d\vec{F} = ?$$

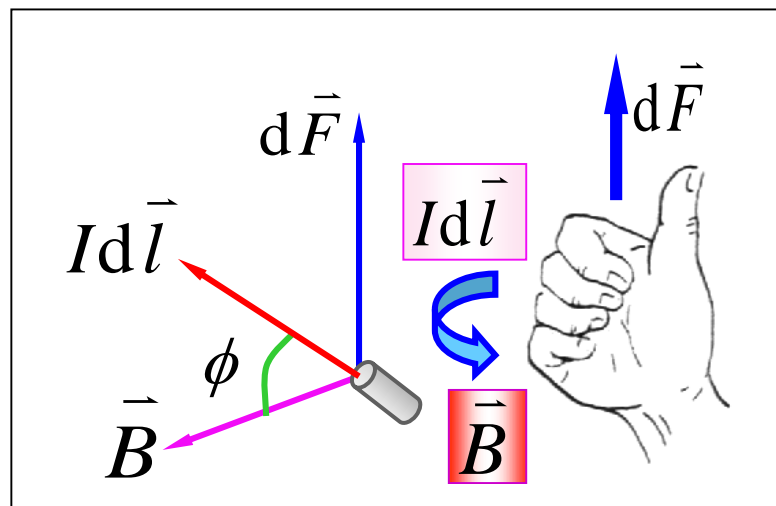
一、安培定律

1、表达式

$$dF = IdlB \sin \phi$$



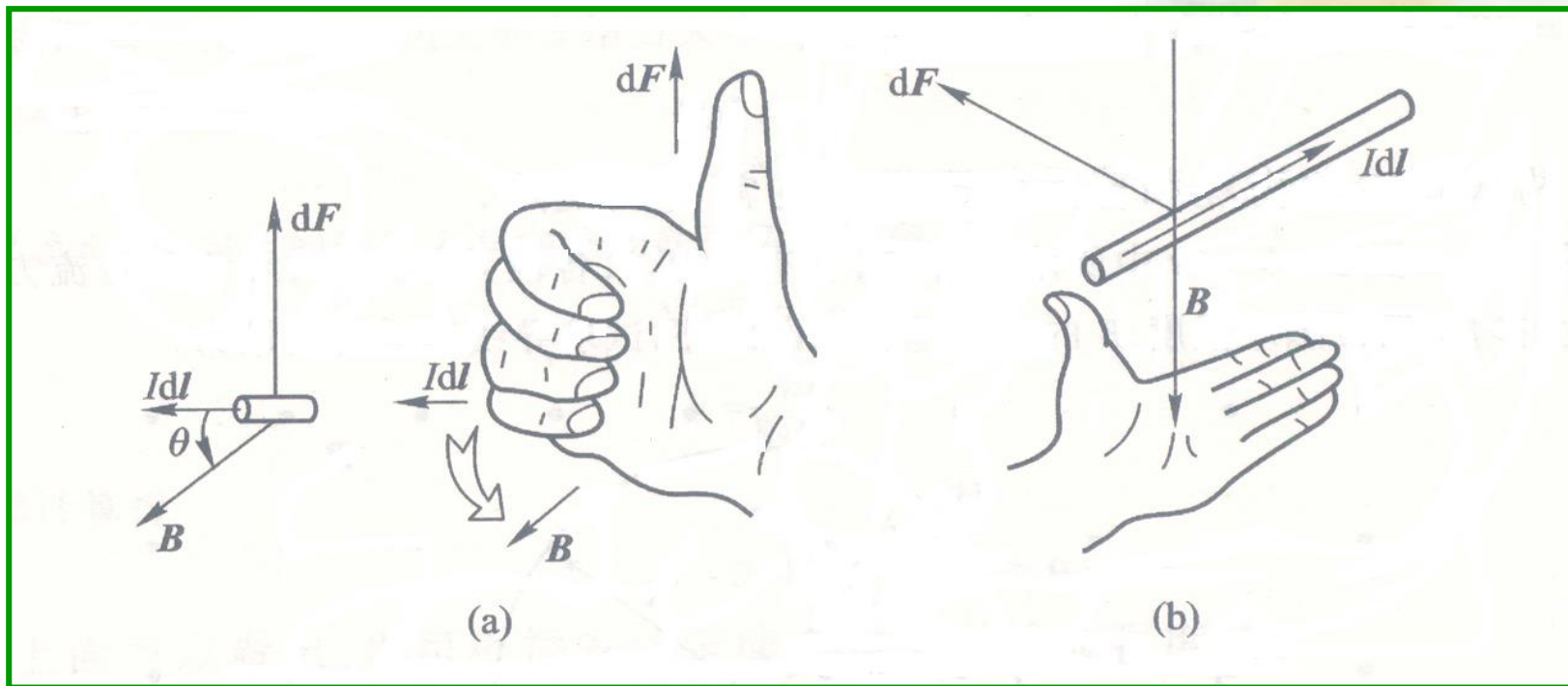
$d\vec{F}$ 方向：
与 $Id\vec{l} \times \vec{B}$ 的方向一致



安培定律的表达式：

$$d\vec{F} = Id\vec{l} \times \vec{B}$$

安培力方向的判定:



①右手螺旋法则;

②左手定则;

2、推导安培力的表达式

洛伦兹力是安培力的微观实质

安培力是洛伦兹力的宏观表现

一个电子: $f_m = ev_d B \sin \theta$



电流元: $dF = nev_d S dl B \sin \theta$



$dF = IdlB \sin \theta$



$dF = IdlB \sin \phi$

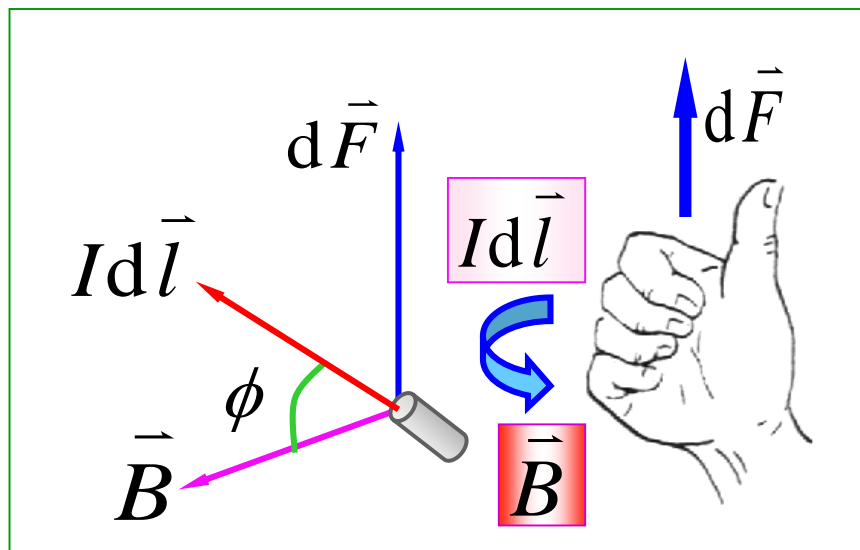
$\because I = nev_d S$

安培定律

电流元在磁场中
所受作用力的规律

$$d\vec{F} = ?$$

$$d\vec{F} = Id\vec{l} \times \vec{B}$$

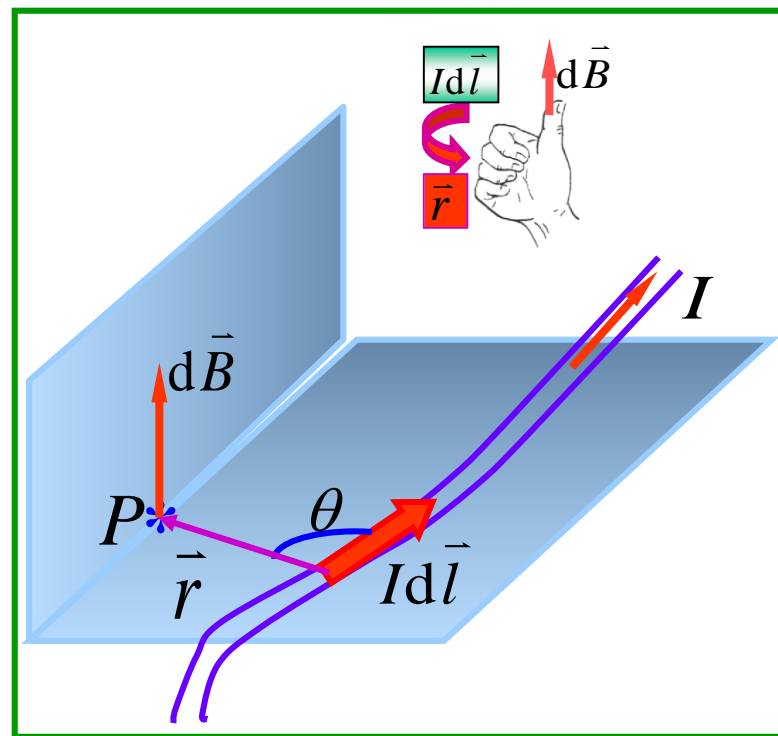


毕奥—萨伐尔定律

电流元在空间
产生的磁场的规律

$$d\vec{B} = ?$$

$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{Id\vec{l} \times \vec{e}_r}{r^2}$$



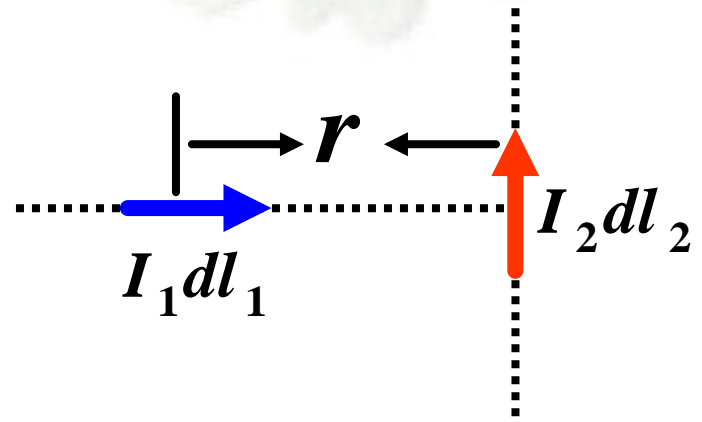
讨论

图示为相互垂直的两个电流元

它们之间的相互作用力？

电流元 $I_1 dl_1$ 所受作用力

$$dF_1 = \frac{\mu_0}{4\pi} \frac{I_1 dl_1 I_2 dl_2}{r^2}$$



电流元 $I_2 dl_2$ 所受作用力

$$dF_2 = \mathbf{0} \quad dF_1 \neq dF_2$$

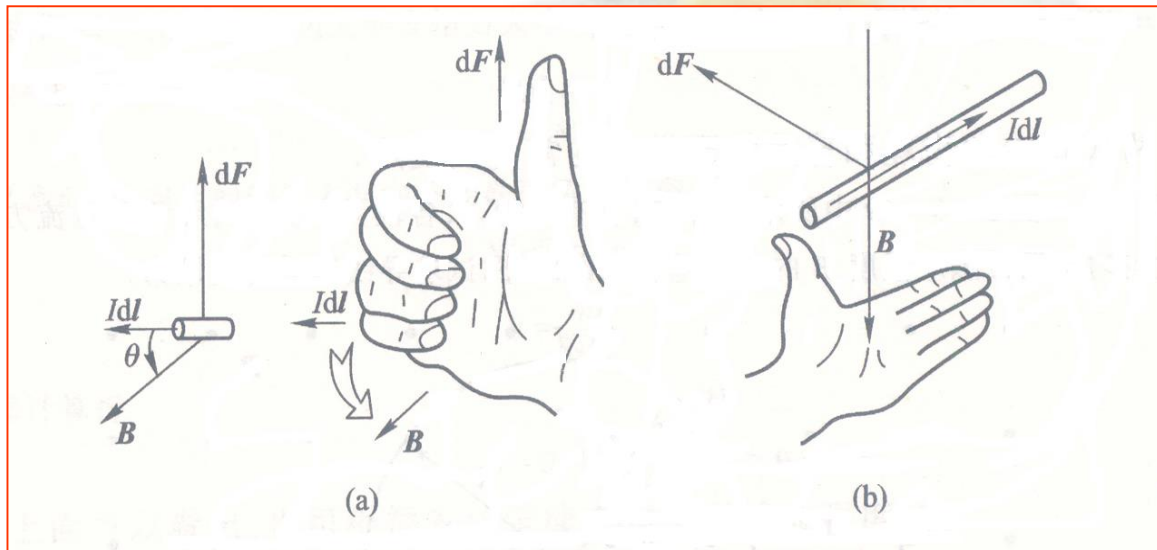
二:任意载流导线所受安培力的计算

$$Id\vec{l} \rightarrow d\vec{F} :$$


$$d\vec{F} = Id\vec{l} \times \vec{B}$$

整段电流 $\rightarrow \vec{F}$:

$$\vec{F} = \int d\vec{F}$$

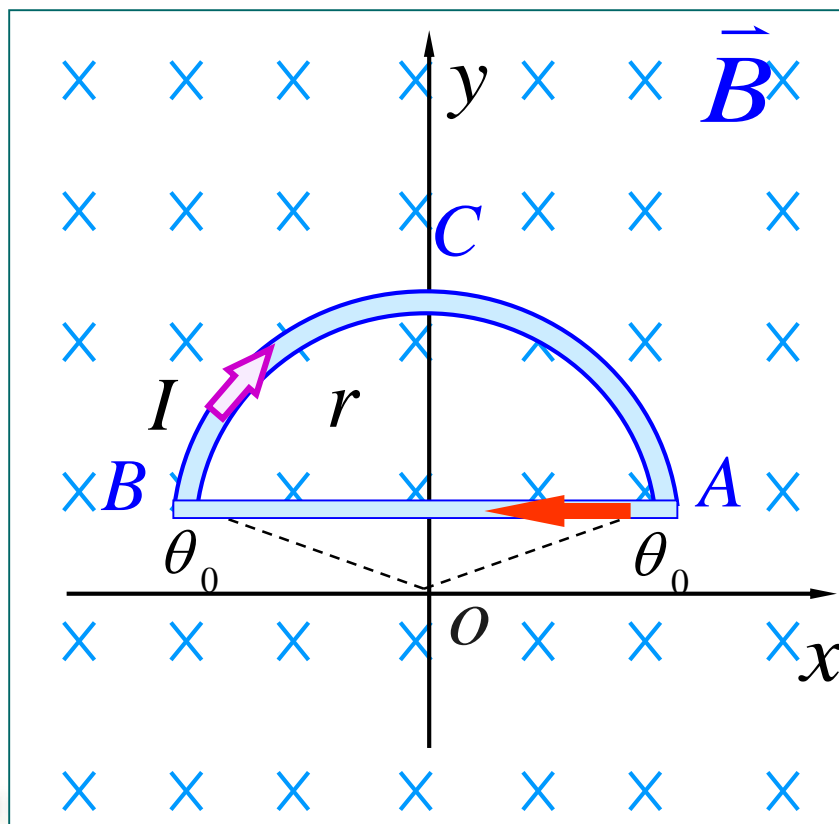


应用时

➤ $\vec{F} = \int d\vec{F}$ 为矢量积分。  需划为标量积分

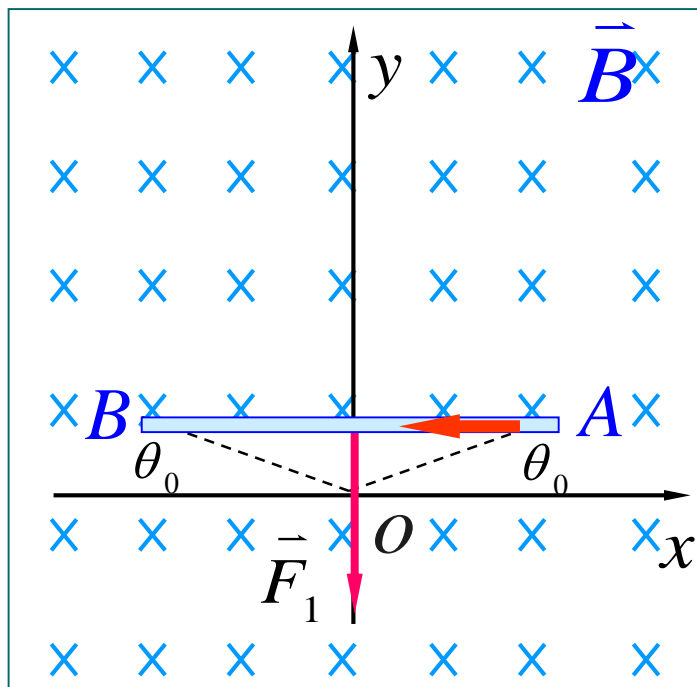
建立坐标系

例 1



求匀强磁场作用于
闭合载流导线的力。

解



$$\begin{aligned} F_1 &= I \overline{AB} B \\ &= IB 2r \cos \theta_0 \end{aligned}$$

$$\vec{F}_1 = -IB (2r \cos \theta_0) \vec{j}$$

根据对称性分析

$$F_{2x} = 0$$

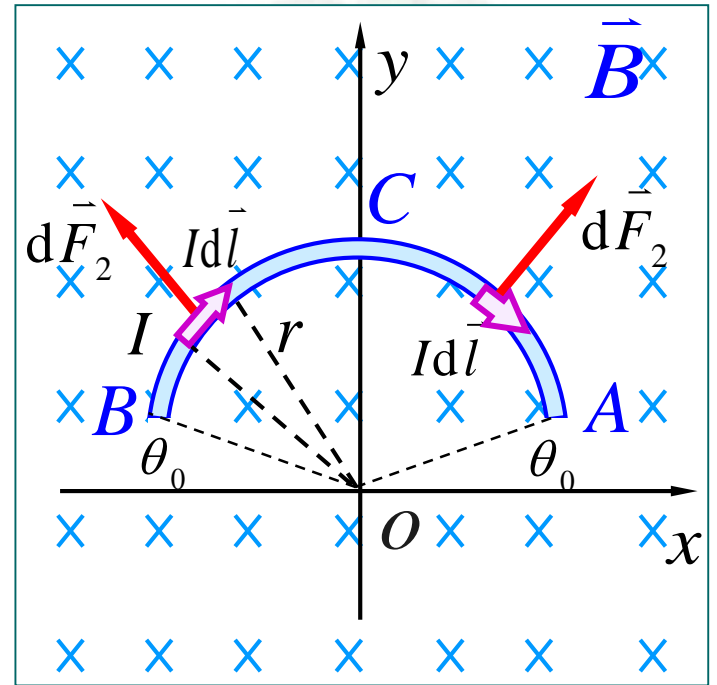
$$\therefore \vec{F}_2 = F_{2y} \vec{j}$$

$$\begin{aligned} F_2 &= \int dF_{2y} = \int dF_2 \sin \theta \\ &= \int BI dl \sin \theta \end{aligned}$$

因 $dl = r d\theta$

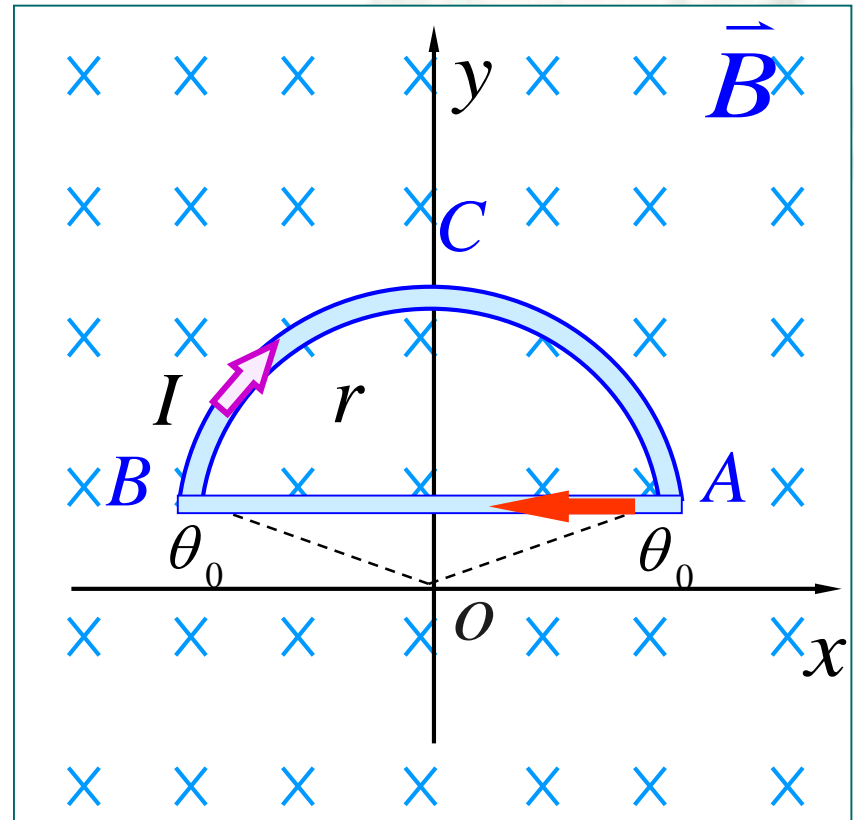
$$F_2 = BI r \int_{\theta_0}^{\pi - \theta_0} \sin \theta d\theta = BI 2r \cos \theta_0$$

$$\vec{F}_2 = BI (2r \cos \theta_0) \vec{j}$$



$$\vec{F}_1 = -IB (2r \cos \theta_0) \vec{j}$$

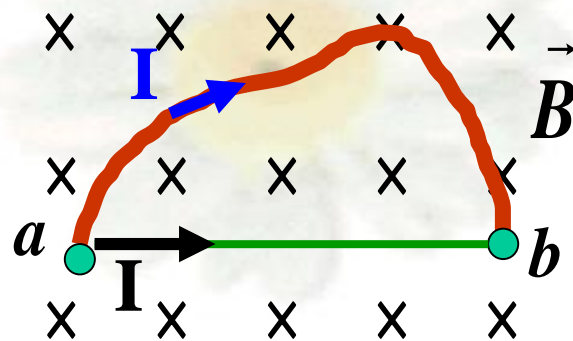
$$\vec{F}_2 = BI (2r \cos \theta_0) \vec{j}$$



故 $\vec{F} = \vec{F}_1 + \vec{F}_2 = 0$

推论1:

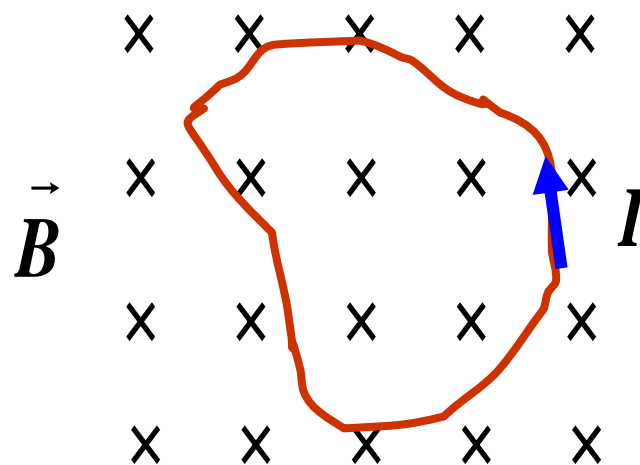
任意形状载流导线在均匀磁场中所受的力，
等于从始点到终点作出载流直导线所受的磁场力相同。



推论2

在均匀磁场中任意形状

闭合载流线圈受合力为零



平行无限长电流间的相互作用？



载流线圈在匀强磁场所受的力矩？

