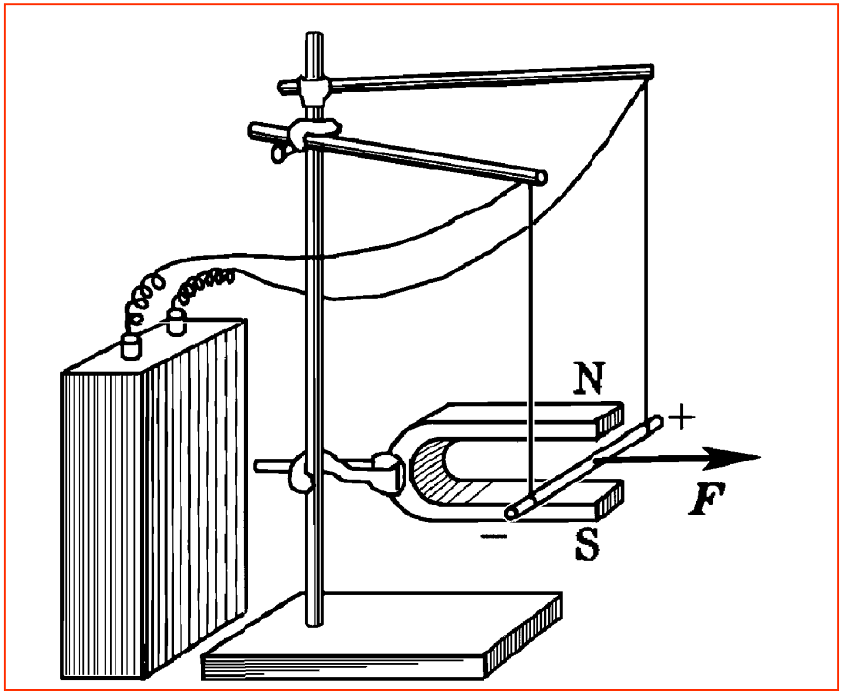
电　流 → 磁场 → 电　流

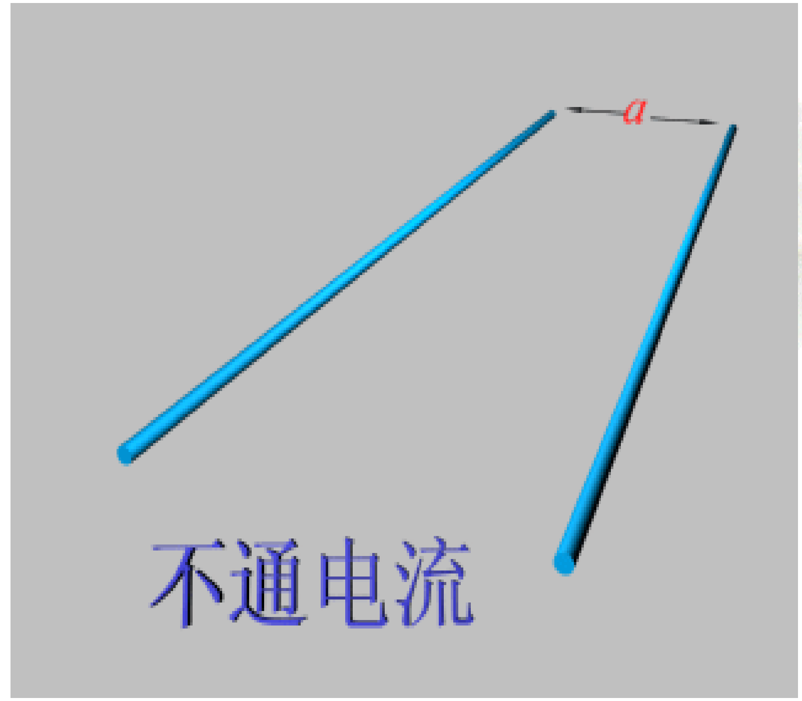
问题一、　已知电流分布，求磁场的分布？

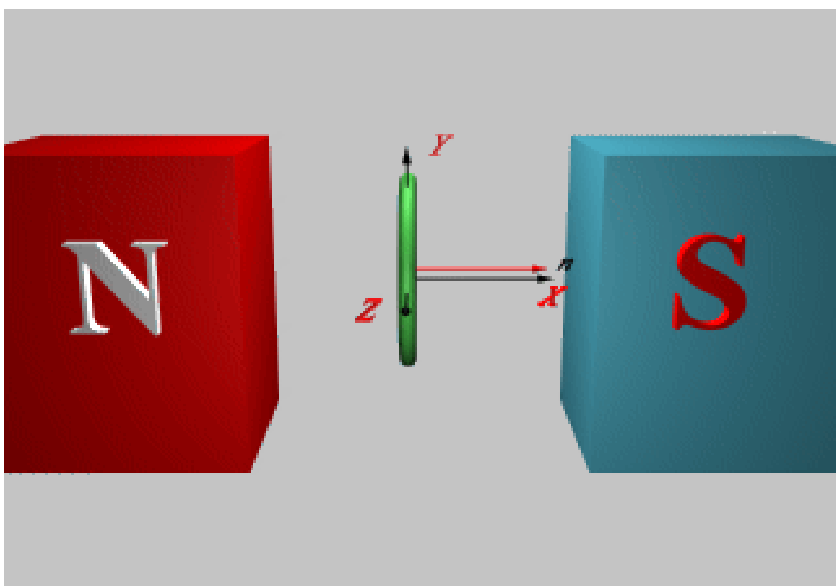
方法一：$\vec{B}=\dfrac{\mu_0}{4\pi}\oint_L \dfrac{Id\vec{l}\times\vec{e}_r}{r^2}$

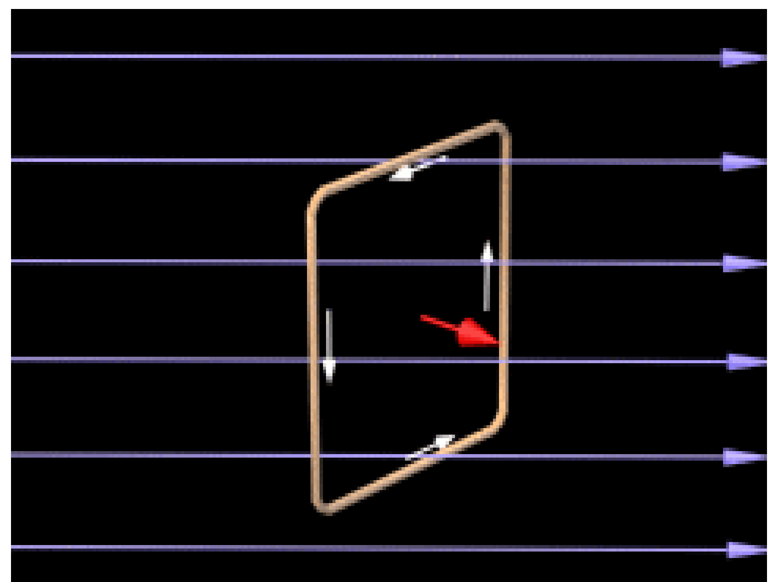
方法二：$\oint_L \vec{B}\cdot d\vec{l}=\mu_0\sum_{(l内)} I_i$　（对称性）

问题二、　已知磁场分布，求对电流的作用力？


N
+
F
−
S

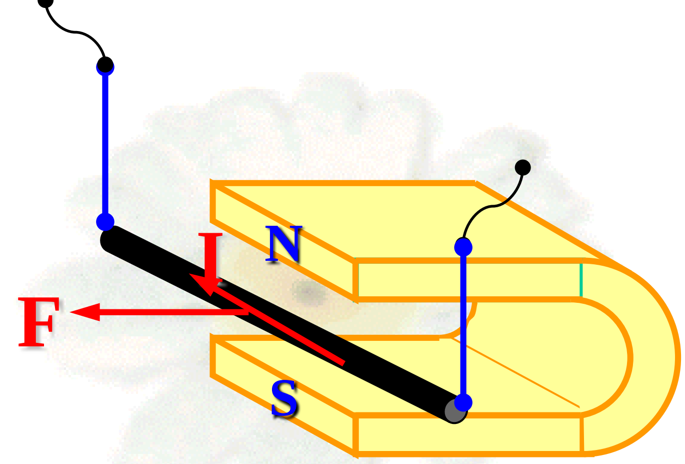

a
不通电流


N
S
Y
Z
X

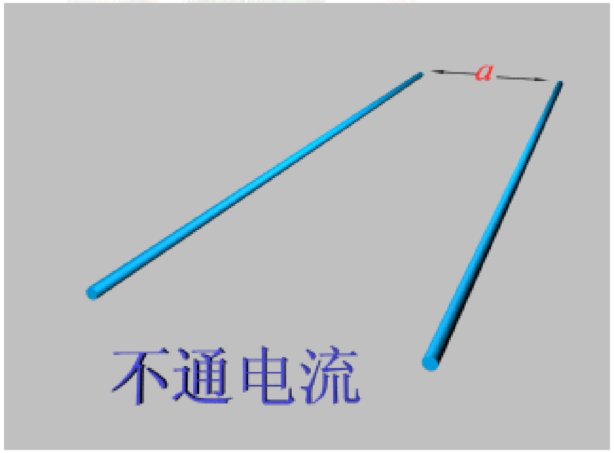


§5-6　磁场对载流导线的作用

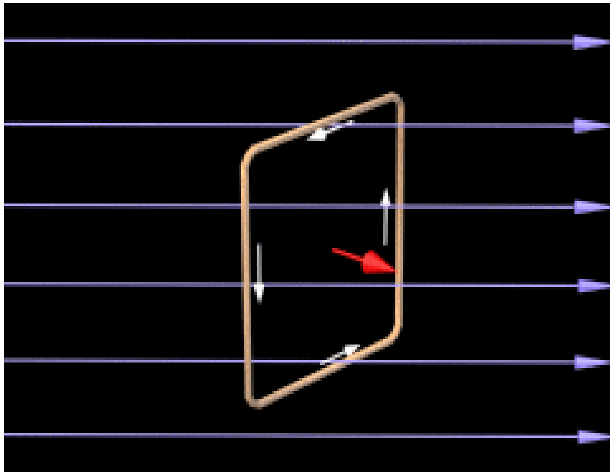
磁场对任意载流导线的作用



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

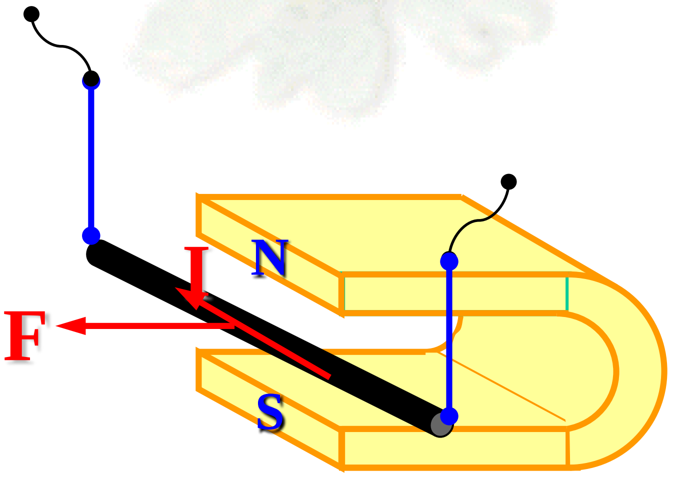


磁场对任意载流导线的作用

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：

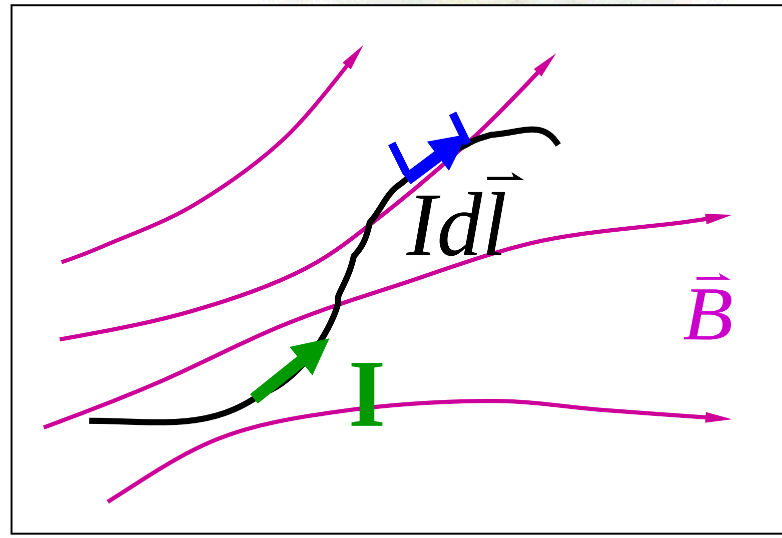
如何求任意载流导线在磁场中所受的作用力？

方法：

任选 $Id\vec{l}$

求出dF ?

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

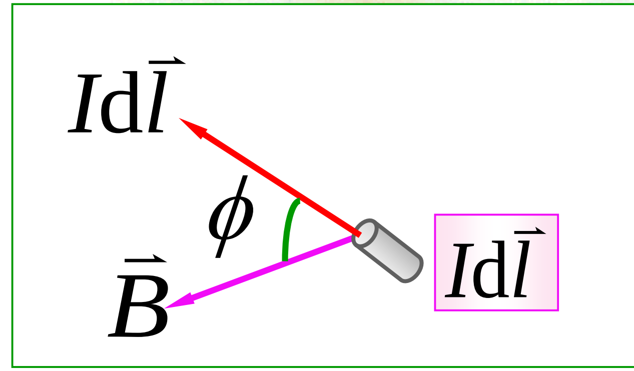


安培定律 → $d\vec{F} = ?$

一、安培定律

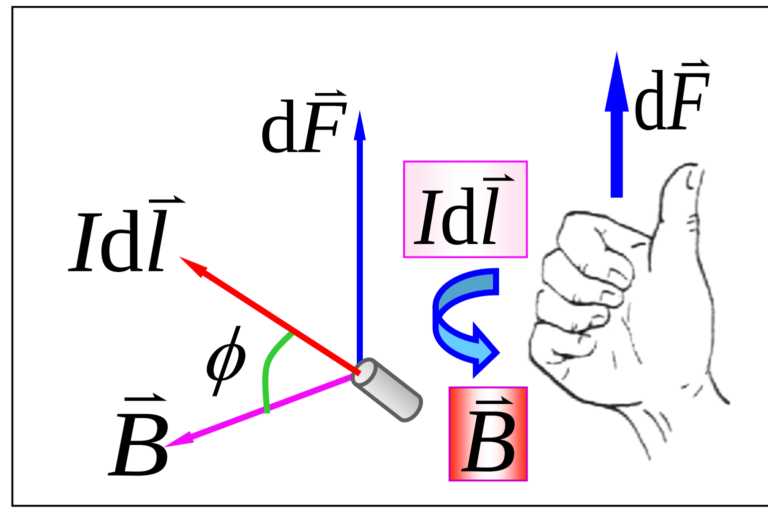
1、表达式

$$\mathrm{d}F = I\mathrm{d}lB\sin\phi$$



$\mathrm{d}\vec{F}$方向：

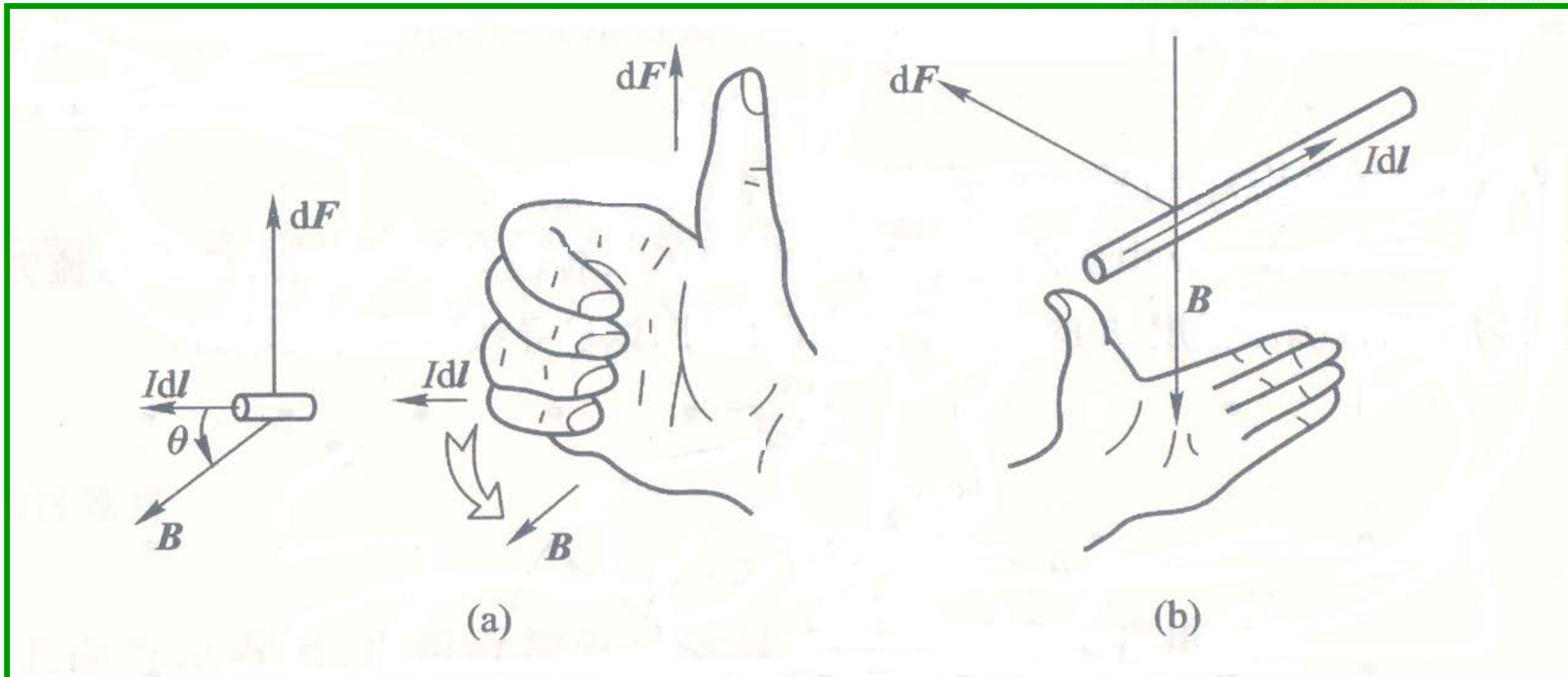
与$I\mathrm{d}\vec{l}\times\vec{B}$的方向一致



安培定律的表达式：

$$\mathrm{d}\vec{F} = I\mathrm{d}\vec{l}\times\vec{B}$$

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：$f_{\mathrm{m}} = ev_{\mathrm{d}}B\sin\theta$

电流元：$\mathrm{d}F = nev_{\mathrm{d}}S\mathrm{d}lB\sin\theta$

$\because I = nev_{\mathrm{d}}S$

$\mathrm{d}F = I\mathrm{d}lB\sin\theta$

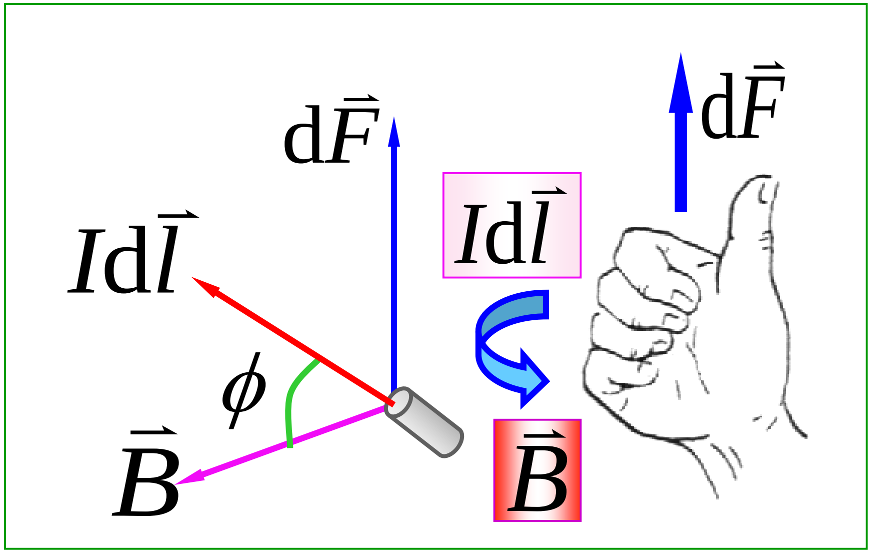
$dF = I\mathrm{d}lB\sin\phi$

安培定律

电流元在磁场中所受作用力的规律

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

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

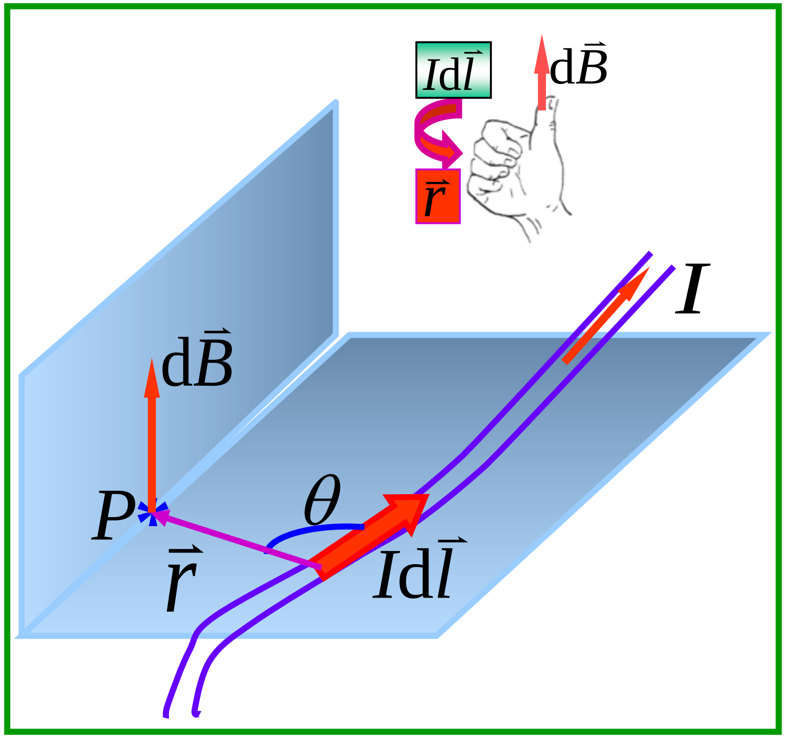


毕奥—萨伐尔定律

电流元在空间产生的磁场的规律

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

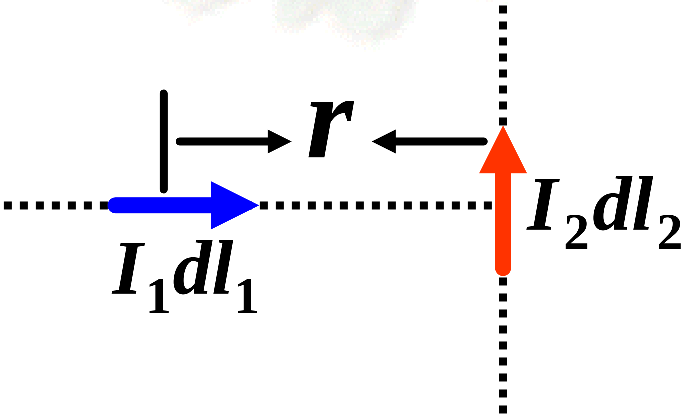
$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{Id\vec{l} \times \vec{e}_r}{r^2}$$



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_1dl_1 所受作用力

$$dF_1 = \frac{\mu_0}{4\pi}\frac{I_1dl_1I_2dl_2}{r^2}$$

电流元 I_2dl_2 所受作用力

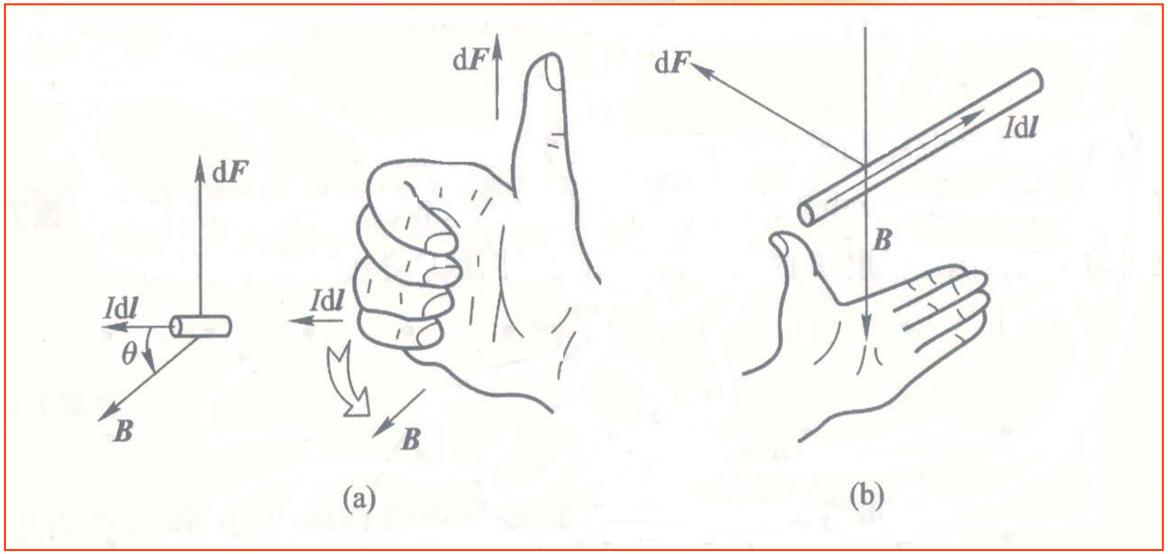
$$dF_2 = 0$$

$$dF_1 \neq dF_2$$

二:任意载流导线所受安培力的计算

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

$$\mathrm{d}\vec{F} = I\mathrm{d}\vec{l} \times \vec{B}$$



整段电流 $\rightarrow \vec{F}$ **:**

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

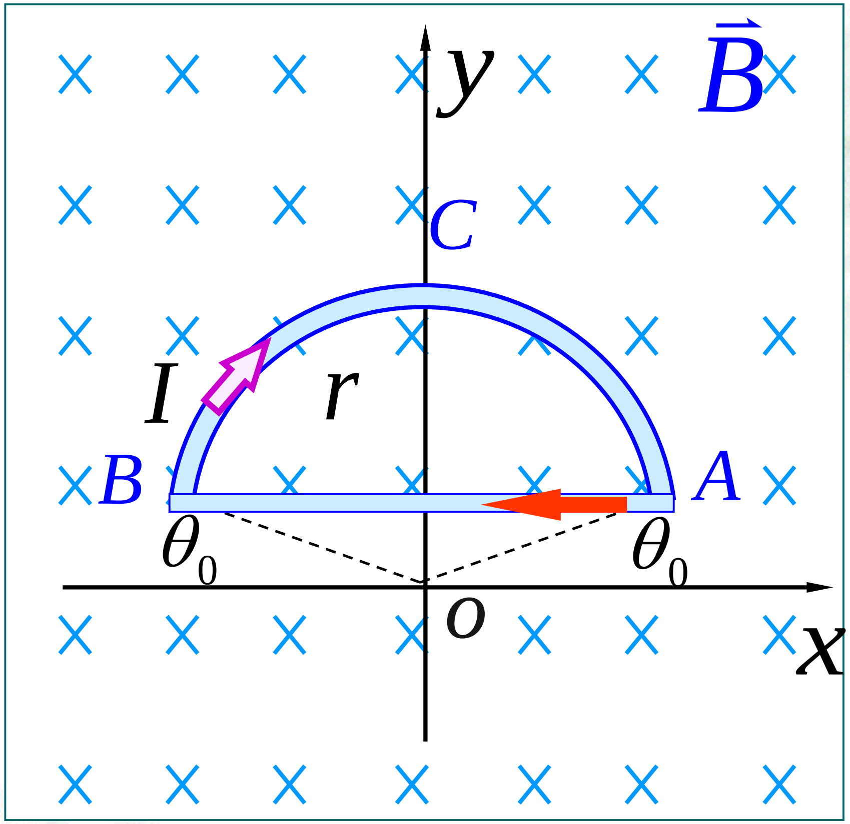
➢ $\vec{F} = \int d\vec{F}$ 为矢量积分。

应用时

建立坐标系

需划为标量积分

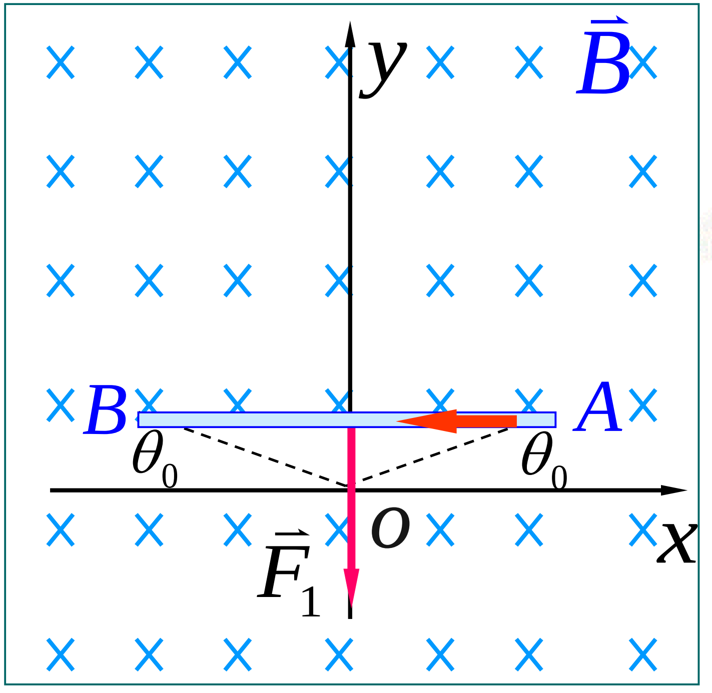
例 1



求匀强磁场作用于

闭合载流导线的力.

解



$$F_1 = I\,\overline{AB}B$$

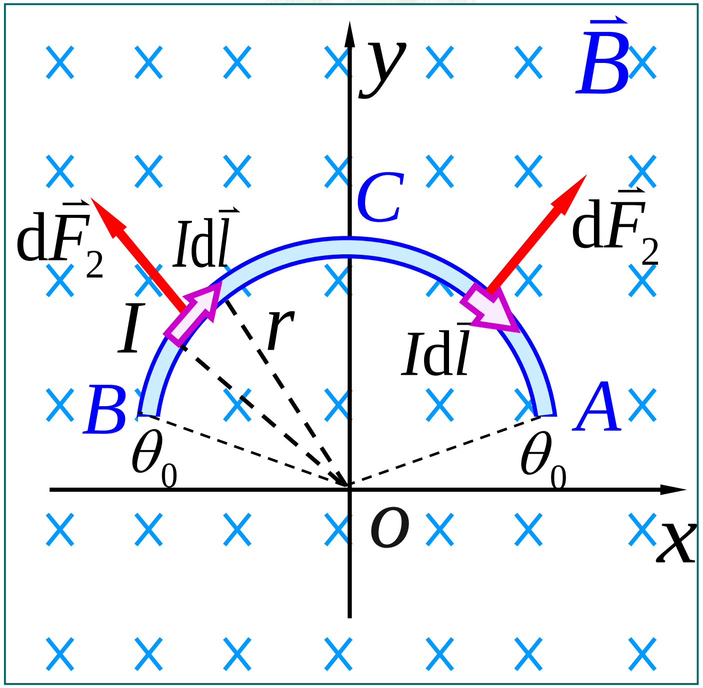
$$= IB2r\cos\theta_0$$

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

根据对称性分析

$$F_{2x} = 0$$

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



$$F_2 = \int \mathrm{d}F_{2y} = \int \mathrm{d}F_2 \sin\theta$$

$$= \int BI\mathrm{d}l \sin\theta$$

因 $\mathrm{d}l = r\mathrm{d}\theta$

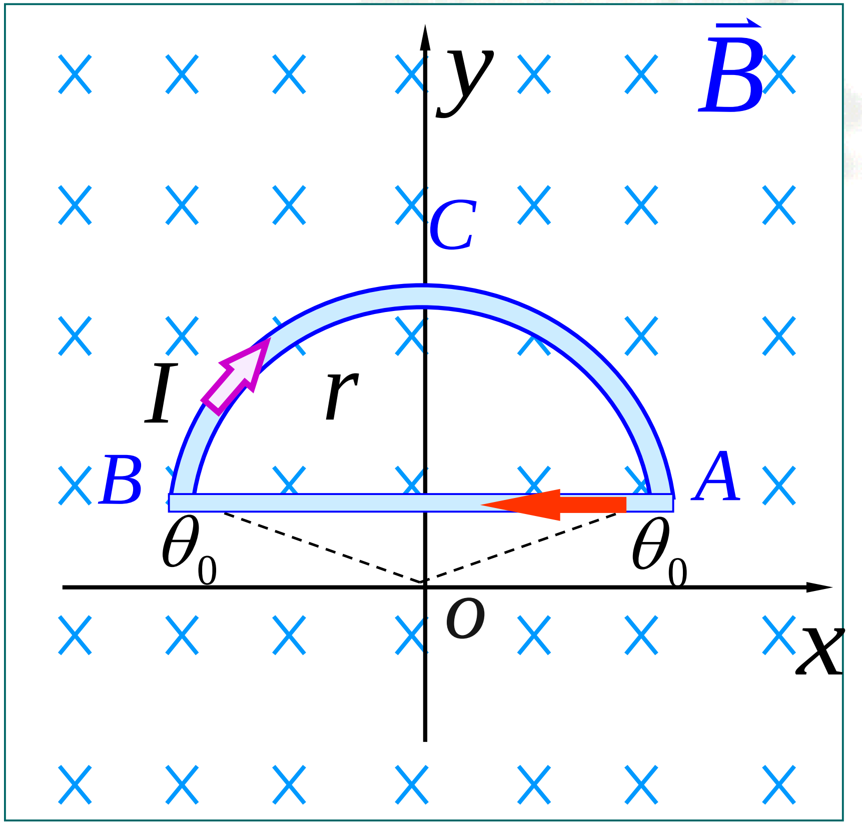
$$F_2 = BIr\int_{\theta_0}^{\pi-\theta_0} \sin\theta\,\mathrm{d}\theta = BI\,2r\cos\theta_0$$

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

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

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

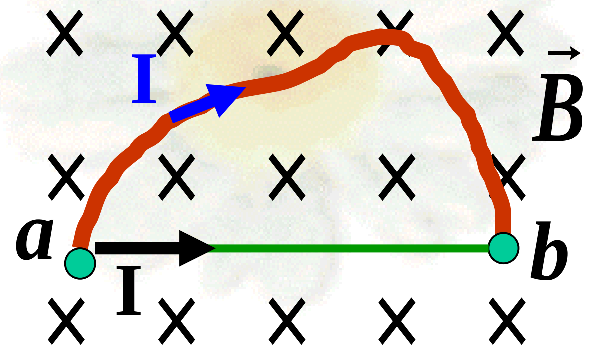
故 $\vec{F} = \vec{F}_1 + \vec{F}_2 = 0$



推论1：

任意形状载流导线在均匀磁场中所受的力，

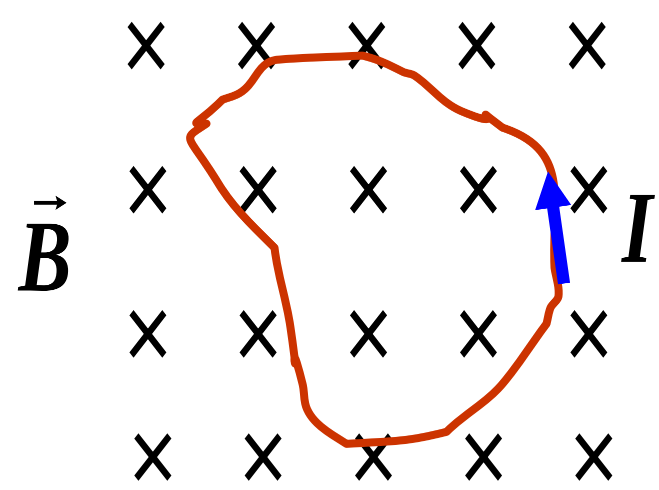
等于从始点到终点作出载流直导线所受的磁场力相同.



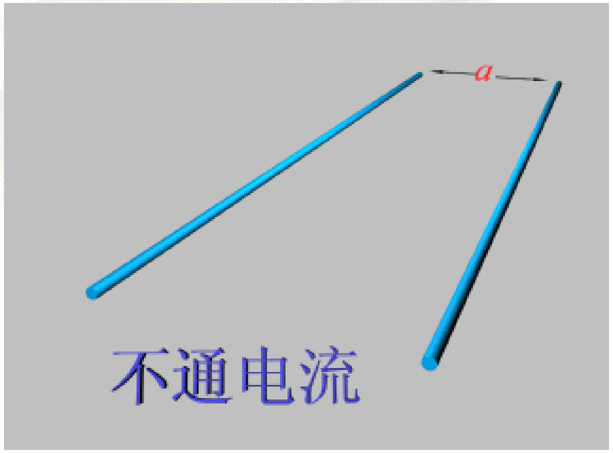
推论2

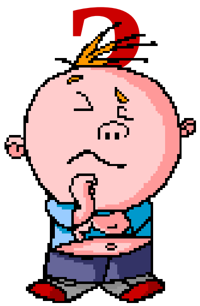
在均匀磁场中任意形状

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？