

一 磁场作用于载流线圈的磁力矩

如图 均匀磁场中有一矩形载流线圈 $MNOP$

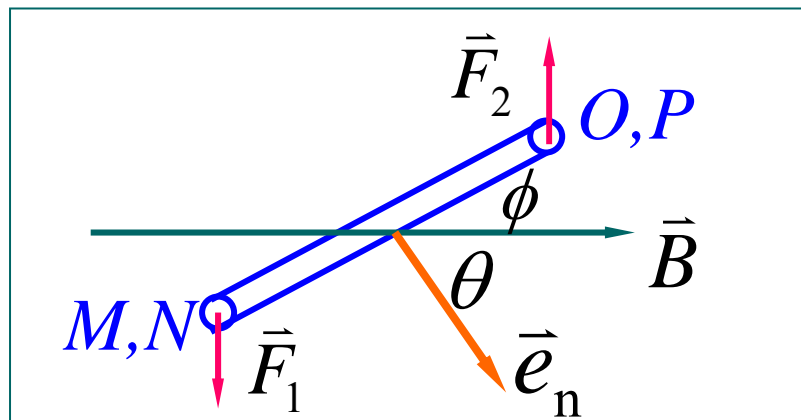
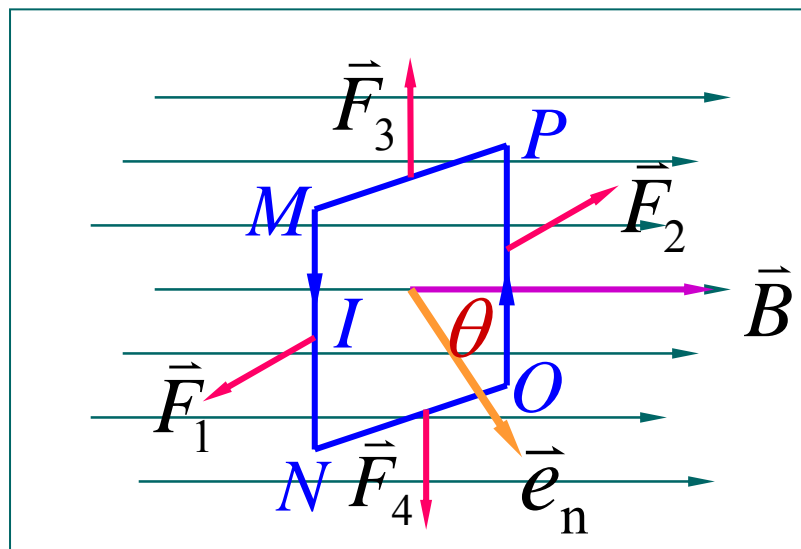
$$MN = l_2 \quad NO = l_1$$

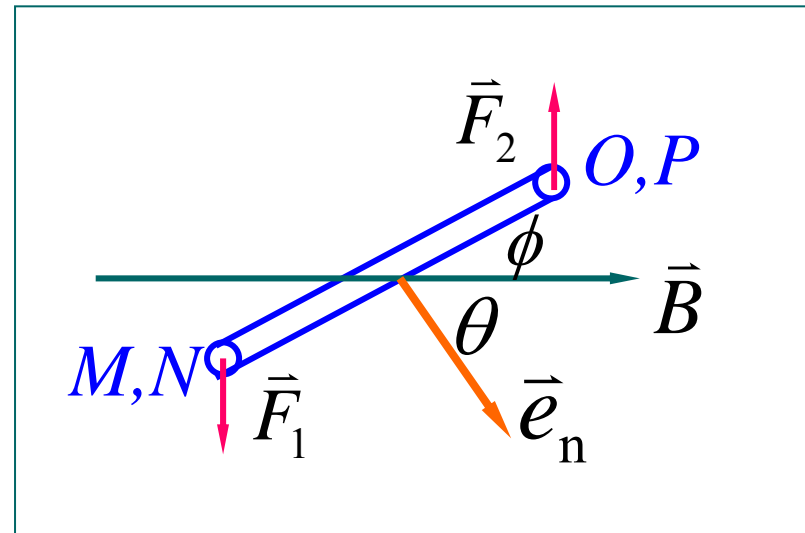
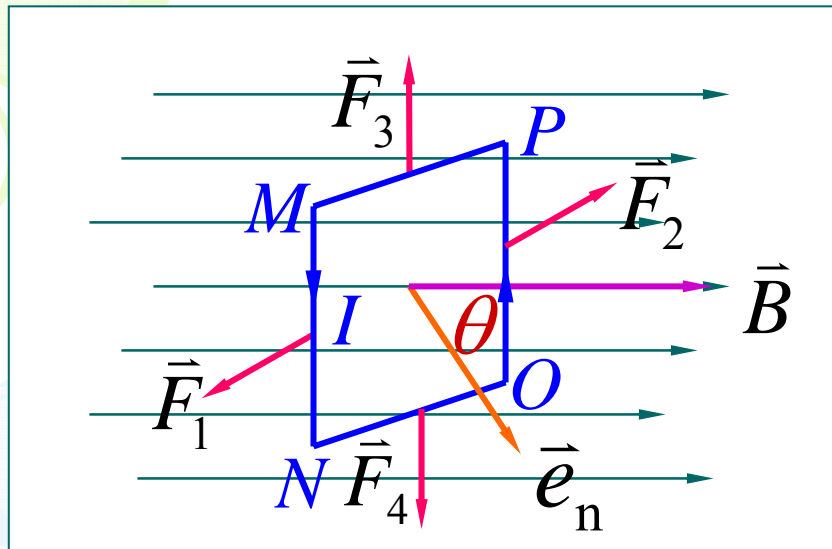
$$F_1 = BIl_2 \quad \vec{F}_1 = -\vec{F}_2$$

$$F_3 = BIl_1 \sin(\pi - \phi)$$

$$\vec{F}_3 = -\vec{F}_4$$

$$\vec{F} = \sum_{i=1}^4 \vec{F}_i = 0$$





$$MN=l_2 \quad NO=l_1 \quad M = F_1 l_1 \sin \theta = B I l_2 l_1 \sin \theta$$

$$M = B I S \sin \theta \quad \vec{M} = I S \vec{e}_n \times \vec{B} = \vec{m} \times \vec{B}$$

线圈有N匝时 $\vec{M} = N I S \vec{e}_n \times \vec{B}$

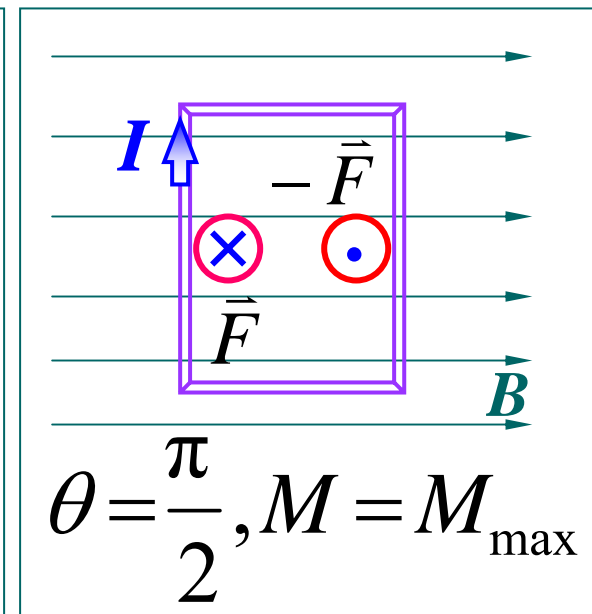
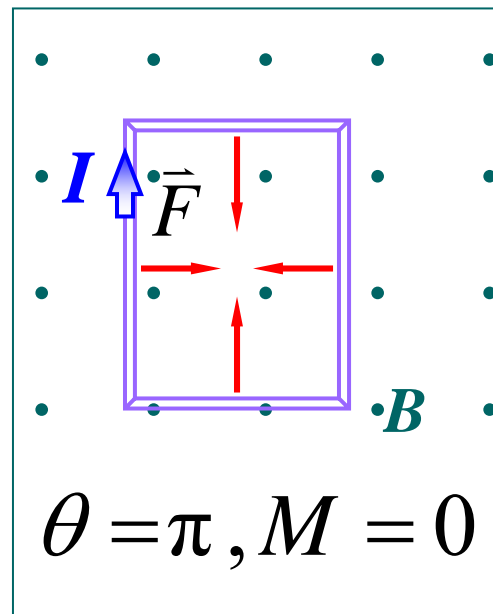
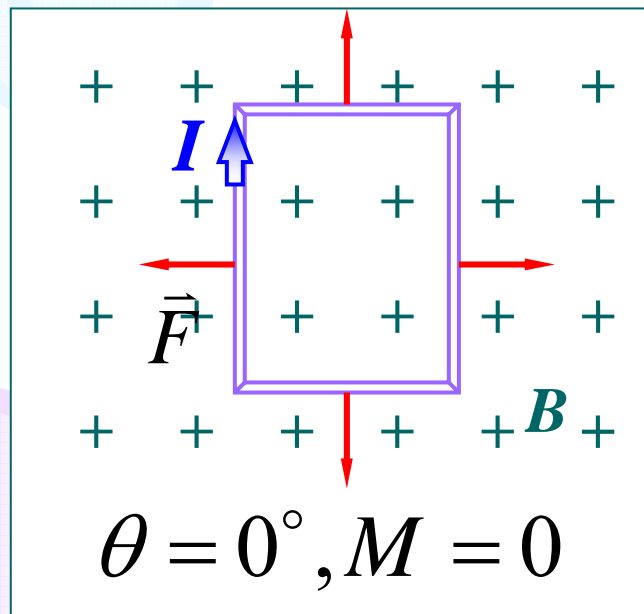
讨论

- 1) \vec{e}_n 方向与 \vec{B} 相同 2) 方向相反 3) 方向垂直

稳定平衡

不稳定平衡

力矩最大



➤ **结论：**均匀磁场中，任意形状刚性闭合平面通电线圈所受的力和力矩为

$$\vec{F} = 0, \quad \vec{M} = \vec{m} \times \vec{B}$$

$$\vec{m} // \vec{B}, \quad \vec{M} = 0 \quad \left\{ \begin{array}{ll} \theta = 0 & \text{稳定平衡} \\ \theta = \pi & \text{非稳定平衡} \end{array} \right.$$

$$\vec{m} \perp \vec{B}, \quad M = M_{\max} = mB, \quad \theta = \pi / 2$$

➤ 磁矩

$$\vec{m} = NIS \vec{e}_n$$

\vec{e}_n 与 I 成右螺旋



例1 边长为0.2m的正方形线圈，共有50匝，通以电流2A，把线圈放在磁感应强度为0.05T的均匀磁场中。问在什么方位时，线圈所受的磁力矩最大？磁力矩等于多少？

解 $M = NBIS\sin\theta$ 得 $\theta = \frac{\pi}{2}, M = M_{\max}$

$$M = NBIS = 50 \times 0.05 \times 2 \times (0.2)^2 \text{ N} \cdot \text{m}$$

$$M = 0.2 \text{ N} \cdot \text{m}$$

问 如果是任意形状载流线圈，结果如何？

例2 如图半径为0.20m，电流为20A，可绕轴旋转的圆形载流线圈放在均匀磁场中，磁感应强度的大小为0.08T，方向沿 x 轴正向.问线圈受力情况怎样？线圈所受的磁力矩又为多少？

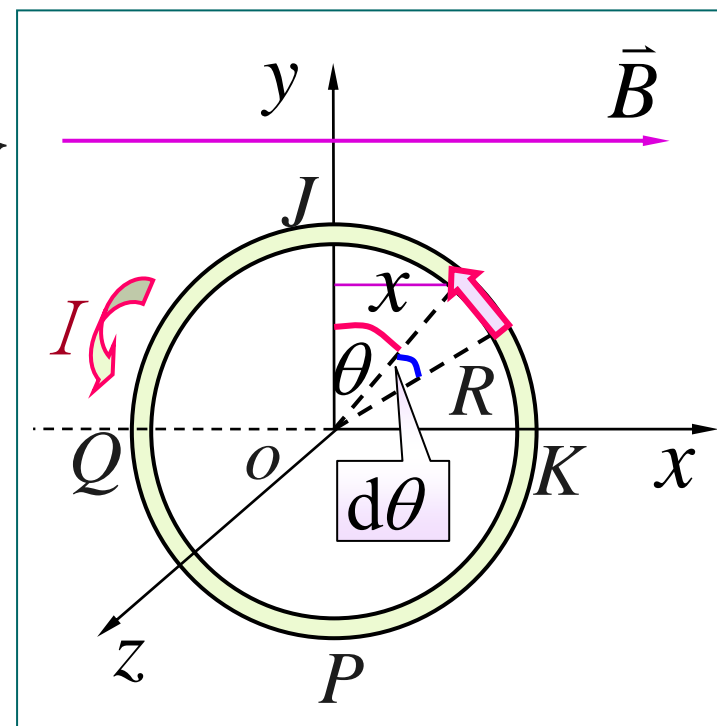
解 把线圈分为 JQP 和 PKJ 两部分

$$\vec{F}_{JQP} = BI(2R)\vec{k} = 0.64\vec{k}\text{N}$$

$$\vec{F}_{PKJ} = -BI(2R)\vec{k} = -0.64\vec{k}\text{N}$$

以 Oy 为轴, $I d\vec{l}$ 所受磁力矩大小

$$dM = x dF = I dl B x \sin \theta \quad x = R \sin \theta, dl = R d\theta$$



$$dM = x dF = I dl B x \sin \theta$$

$$x = R \sin \theta, dl = R d\theta$$

$$dM = I B R^2 \sin^2 \theta d\theta$$

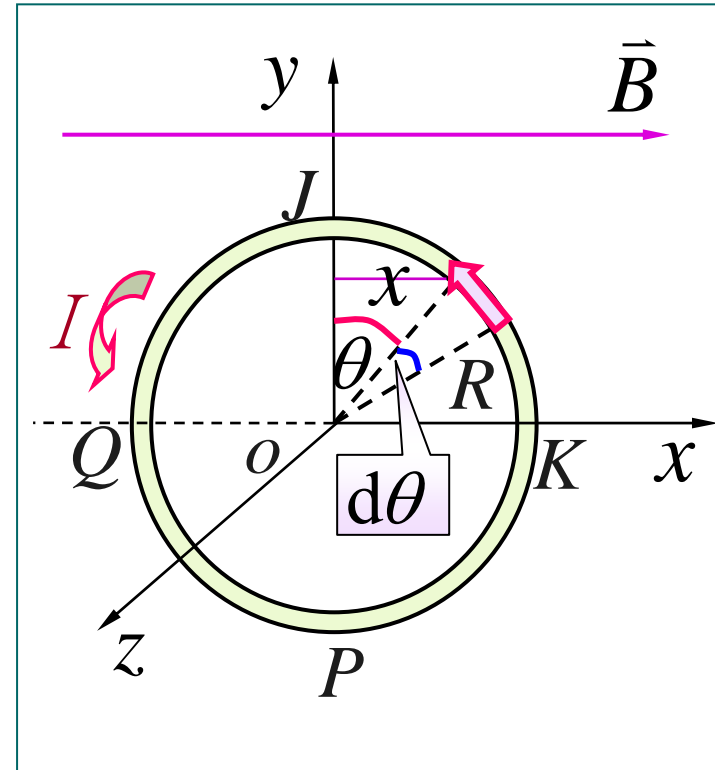
$$M = I B R^2 \int_0^{2\pi} \sin^2 \theta d\theta$$

$$M = I B \pi R^2$$

$$\vec{m} = I S \vec{k} = I \pi R^2 \vec{k}$$

$$\vec{B} = B \vec{i}$$

$$\vec{M} = \vec{m} \times \vec{B} = I \pi R^2 B \vec{k} \times \vec{i} = I \pi R^2 B \vec{j}$$



二 磁电式电流计原理

实验测定 游丝的反抗力矩与线圈转过的角度成正比。



$$M' = a\theta$$

$$BNIS = a\theta$$

$$I = \frac{a}{NBS} \theta = K\theta$$

