

一 单摆

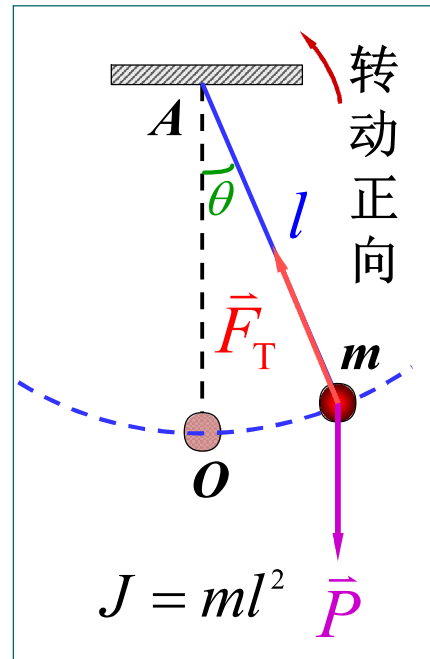
动力学分析:

$$\theta < 5^\circ \text{ 时, } \sin \theta \approx \theta$$

$$M = -mgl \sin \theta \approx -mgl \theta$$

$$-mgl \theta = J \frac{d^2 \theta}{dt^2}$$

$$\rightarrow \frac{d^2 \theta}{dt^2} = -\frac{g}{l} \theta$$



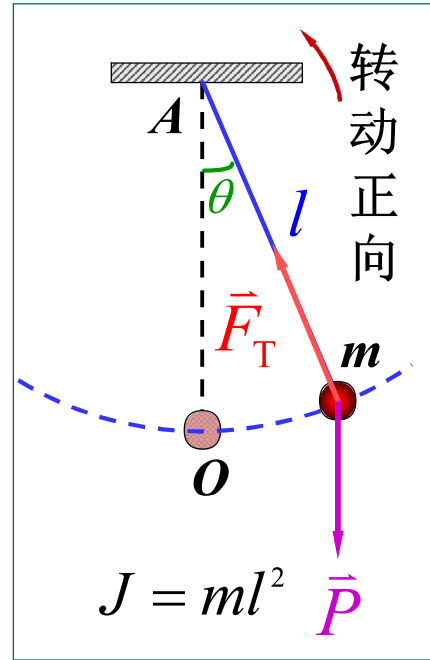
$$\frac{d^2\theta}{dt^2} = -\frac{g}{l}\theta$$

$$\text{令 } \omega^2 = \frac{g}{l}$$

$$\frac{d^2\theta}{dt^2} = -\omega^2\theta$$

$$\theta = \theta_m \cos(\omega t + \varphi)$$

$$T = 2\pi \sqrt{\frac{l}{g}}$$



二 复摆 ($\theta < 5^\circ$)

$$\vec{M} = \vec{l} \times \vec{F}$$

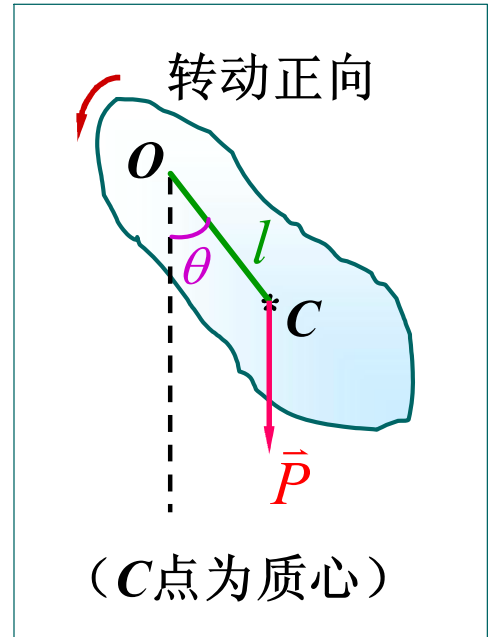
$$M = -mgl \sin \theta$$

$$= J\beta = J \frac{d^2\theta}{dt^2}$$

$$-mgl \theta = J \frac{d^2\theta}{dt^2}$$

$$\text{令 } \omega^2 = \frac{mgl}{J}$$

$$\frac{d^2\theta}{dt^2} = -\omega^2\theta$$



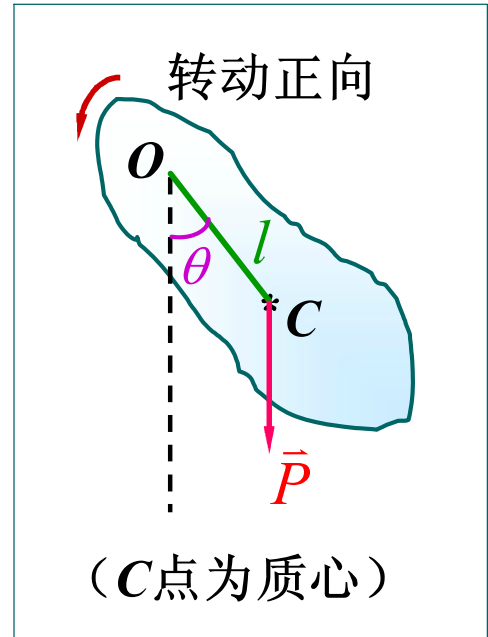
$$\frac{d^2\theta}{dt^2} = -\omega^2\theta$$

$$\omega = \sqrt{\frac{mgl}{J}}$$

$$\Rightarrow T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{J}{mgl}}$$

$$T = 2\pi\sqrt{\frac{J}{mgl}}$$

$$\theta = \theta_m \cos(\omega t + \varphi) \quad \text{角谐振动}$$



三 简谐运动的方程和特征

(1) 物体受线性回复力作用 $F = -kx$

平衡位置 $x = 0$

(2) 简谐运动的动力学方程 $\frac{d^2 x}{dt^2} = -\omega^2 x$

(3) 简谐运动的运动学方程

$$x = A \cos(\omega t + \varphi)$$

$$v = -A \omega \sin(\omega t + \varphi)$$

(4) 加速度与位移成正比而方向相反

$$a = -\omega^2 x$$



弹簧振子 $\omega = \sqrt{k/m}$

单摆 $\omega = \sqrt{g/l}$

复摆 $\omega = \sqrt{mgl/J}$



选择进入下一节:

9-2 旋转矢量

9-3 单摆和复摆

9-4 简谐运动的能量

9-5 简谐运动的合成

9-6 阻尼振动 受迫振动 共振

9-7 电磁振荡

