

25.4: Cylinder Rolling Inside another Cylinder

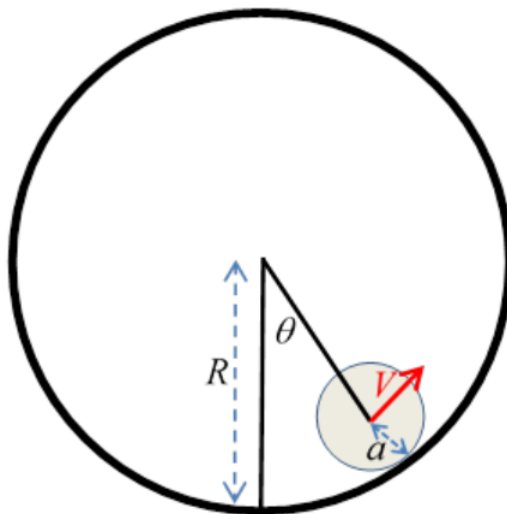


Figure 25.4.1

Now consider a solid cylinder radius a rolling inside a hollow cylinder radius R , angular distance from the lowest point θ , the solid cylinder axis moving at $V = (R - a)\dot{\theta}$ and therefore having angular velocity (compute about the point of contact) $\Omega = V/a$.

The kinetic energy is

$$\frac{1}{2}MV^2 + \frac{1}{2}I(V/a)^2 = \frac{1}{2}\left(M + \frac{I}{a^2}\right)(R - a)^2\dot{\theta}^2 \quad (25.4.1)$$

The potential energy is $-Mg(R - a)\cos\theta$.

The Lagrangian $L = T - V$, the equation of motion is

$$\left(M + \frac{I}{a^2}\right)(R - a)^2\ddot{\theta} = -Mg(R - a)\sin\theta \cong -Mg(R - a)\theta \quad (25.4.2)$$

so small oscillations are at frequency $\omega = \sqrt{\frac{g}{\left(1 + \frac{I}{Ma^2}\right)(R - a)}}$.

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