Kinetics of Rigid Bodies

Using the mass center $G$

\[ \sum F = m\ddot{a}_G \]

\[ \sum \dot{M}_G = I_G\ddot{a} \]

Special Case: Pure Translation

\[ \Rightarrow \ddot{a} = 0 \]

\[ \therefore \sum F = m\ddot{a}_G \]

\[ \sum \dot{M}_G = 0 \]

Using a fixed point $O$

\[ \sum F = m\ddot{a}_G \]

\[ \sum \dot{M}_O = I_O\ddot{a} \]

Special Case: Pure Rotation

Then the axis of rotation is the fixed point.

Use of Normal & Tangential Coordinates is useful

Frictional Rolling Problems

- Rolling can be considered as the sum:
  - Of Pure Translation
  - And Pure Rotation

Kinematics

- If a wheel rolls without slipping
  - $V_{CM}$
  - $R$
  - $\omega$

Kinetics

Let's examine the case of a uniform disk (or wheel, or cylinder, or sphere, etc.) moving on a flat horizontal surface that is subjected to a constant horizontal force.

We have 3 equations and 4 unknowns ($F$, $N$, $\alpha$, and $a_G$). We need one more equation.

Again, all of the above ONLY applies if the wheel rolls without slipping!
The 8.0 kg spool has a radius of gyration $k_G = 0.35$ m. If the ropes have negligible mass, determine the acceleration of the mass center $G$. Assume 3 SF.

The 60 lb wheel has a radius of gyration $k_G = 0.70$ ft. If a 35 ft-lb torque is applied to the wheel, determine the acceleration of the mass center $G$. The coefficients of static and kinetic friction are $\mu_s = 0.30$ and $\mu_k = 0.30$ respectively.