

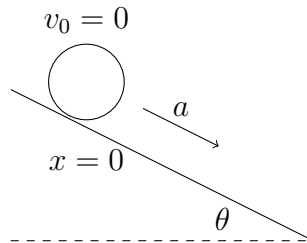
# University Physics 1A

Alvin Lin

November 9th, 2017

## Torque

To calculate the acceleration of an object rolling down a ramp.



$$N - mg \cos \theta = 0$$

$$mg \sin \theta - f = ma$$

$$fr = \tau = I\alpha$$

$$a = r\alpha$$

$$= r \frac{fr}{I}$$

$$= \frac{r^2}{I} (mg \sin \theta - ma)$$

$$a \left(1 + \frac{mr^2}{I}\right) = \frac{r^2 mg \sin \theta}{I}$$

$$a = \frac{r^2 mg \sin \theta}{I} \frac{1}{\left(1 + \frac{mr^2}{I}\right)}$$

$$= \frac{r^2 mg \sin \theta}{I + mr^2}$$

Using Conservation of Energy:

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\frac{v^2}{r^2}$$

$$mgh = \left(\frac{1}{2}m + \frac{I}{2r^2}\right)v^2$$

$$gh = \frac{1}{2}\left(1 + \frac{I}{mr^2}\right)v^2$$

$$v^2 = \frac{2gh}{1 + \frac{I}{mr^2}}$$

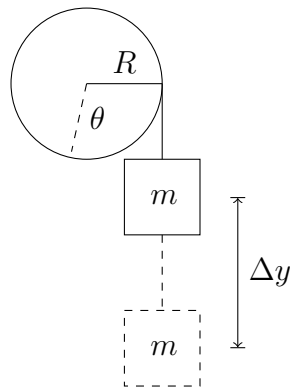
Plugging into the kinematic equations:

$$v_f^2 = v_i^2 + 2a(\Delta x)$$

$$\frac{2gh}{1 + \frac{I}{mr^2}} = 2a\frac{h}{\sin\theta}$$

$$a = \frac{g\sin\theta}{1 + \frac{I}{mr^2}}$$
$$= \frac{mg\sin\theta}{m + \frac{I}{r^2}}$$

## Experiment



Find a formula for  $I$  in terms of  $\alpha$ .

$$\begin{aligned}\Delta y &= s = R\theta \\ -\frac{I\alpha}{R} - mg &= ma \\ &= mR\alpha \\ -\frac{I\alpha}{R} - mR\alpha &= mg \\ -\frac{I\alpha}{R} &= mg + mR\alpha \\ I &= -\frac{R}{\alpha}(mg + mR\alpha) \\ &= -\frac{mgR}{\alpha} - mR^2\end{aligned}$$

You can find all my notes at <http://omgimanerd.tech/notes>. If you have any questions, comments, or concerns, please contact me at [alvin@omgimanerd.tech](mailto:alvin@omgimanerd.tech)