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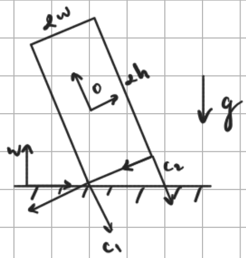

$q = [x, y, \theta]^T$

$$M = \begin{bmatrix} m & 0 & 0 \\ 0 & m & 0 \\ 0 & 0 & I_{o,z} \end{bmatrix}$$

$$I_{o,z} = \frac{m}{12}\left((2w)^2 + (2h)^2\right) = \frac{m}{3}(w^2+h^2)$$

$$\Rightarrow M = \begin{bmatrix} m & 0 & 0 \\ 0 & m & 0 \\ 0 & 0 & \frac{m}{3}(w^2+h^2) \end{bmatrix}$$

Contact modes:

i) before impact: $a_1 = y - h\cos\theta - w\sin\theta$

ii) After impact: a_1 and $a_2 = y - h\cos\theta + w\sin\theta$

$$\text{So } A = \begin{bmatrix} \partial a_1/\partial q \\ \partial a_2/\partial q \end{bmatrix} = \begin{bmatrix} 0 & 1 & h\sin\theta - w\cos\theta \\ 0 & 1 & h\sin\theta + w\cos\theta \end{bmatrix}\Bigg|_{\theta=0}$$

$$\rightarrow A = \begin{bmatrix} 0 & 1 & -w \\ 0 & 1 & w \end{bmatrix}$$

Since while analyzing the impact, we are assuming that only the velocity and other higher derivative terms are changing, the other terms can be ignored.

$$\dot q^+ = \dot q^- - A^{\dagger T} A \dot q^-$$
$$\hat p = A^{\dagger} M \dot q^-$$

Wide block: assume both modes are active at the time of impact

Narrow block:

case 1: assume both modes are active at the time of impact

case 2: assume the block tips over and only mode 2 is active at the time of impact.