The Falling Cat.

FALL Break!

NOT SURE

HOW YOU DOING THAT

~Marey, 1894
(probably)
Newton-Euler Equations

Newton said:

1. \( \dot{P}_i = \dot{P}_0 \)

2. \( \bar{F} = \dot{\bar{p}} \) (= \( m\ddot{a} \))

3. \( \bar{F} = -R \)

Euler:

1. \( \mathbf{\Sigma F}_{ext} = \dot{\bar{p}} \)

2. \( \mathbf{\Sigma M}_{ext} = \dot{\bar{H}} \)

N-E:

\[
\begin{pmatrix}
\dot{\bar{F}} \\
\dot{\bar{T}}
\end{pmatrix} =
\begin{pmatrix}
m I & 0 \\
0 & I_a
\end{pmatrix}
\begin{pmatrix}
\dot{\bar{a}}_a \\
\dot{\bar{W}}
\end{pmatrix} +
\begin{pmatrix}
0 \\
\bar{W} \times I_a \bar{\omega}
\end{pmatrix}
\]
Cats usually don't walk backwards. In this film they don't. My favorite part is when they show the cat at the door way when it's raining and black out. Staring east. What's over there we all ask (viewer's). It doesn't matter.

- catpantry, Jan 2020
See "Smarter Every Day" Videos

\[ \dot{H} = 0 = I_F \dot{\omega}_F + I_B \dot{\omega}_B \]

Front legs held close

Back legs extended

Front legs extend

Back legs retract relative to rotation axis

Back legs extend for landing
Cats aren’t rigid objects!

Rigid objects are often analyzed with holonomic constraints.

“Configuration constraints” only effect the relative position and time of objects.

Examples:

- 2 particles: 4 DoF - 1 constraint = 3 DoF
  \[ x_a, y_a, \theta \]

- 4 rigid objects: 4 \times 3 = 12 possible DoFs

But this has 1 DoF!

“Grubler’s Formula”
Non-holonomic Constraints

Limit the higher order derivatives of the system.

Example

Cars can go anywhere, \((\ddot{x}, \ddot{y}, \ddot{\theta})\)
but not in anyway \((\dddot{\theta} \text{ is limited})\)

Rolling disk with no sliding.
Scleronomic Constraints

A constraint that is independent of time

Rheonomic Constraints

Constraints that explicitly dependent on time