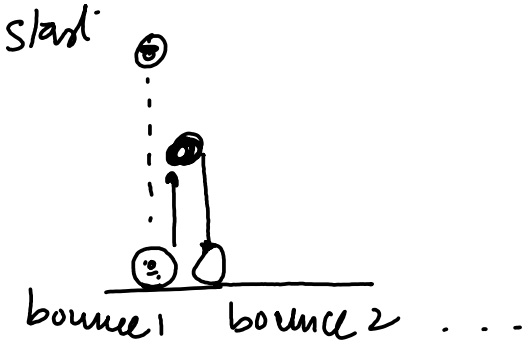
2D Legged systems

Hybrid system — system with different modes

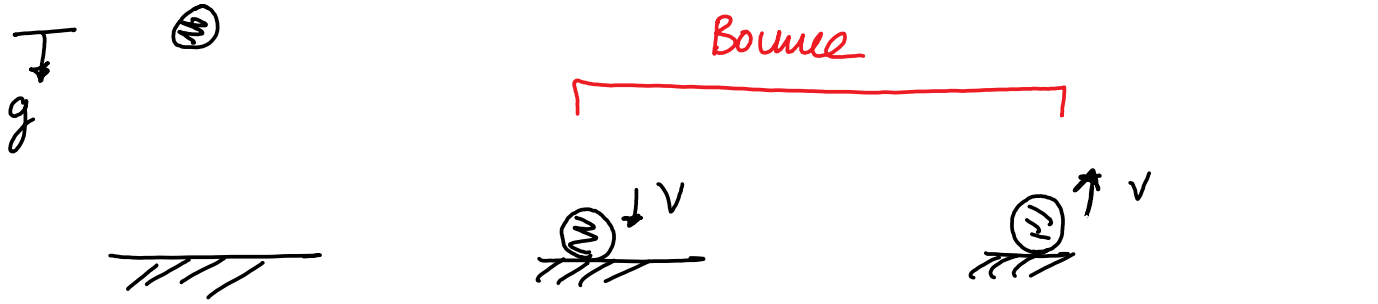
e.g. ball bouncing on the floor.
legged system such as bipeds, quadrupeds.

Example - Bouncing ball



How do we analyze / simulate such a system

Analysis

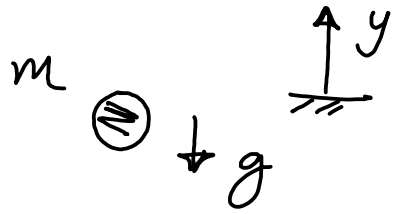


Free fall $\xrightarrow{\text{detect ground}}$ Bounce $\longrightarrow$ Free fall $\xrightarrow{\text{detect ground}}$ Bounce $\longrightarrow$

$y = 0$

one complete bounce (repeating unit)

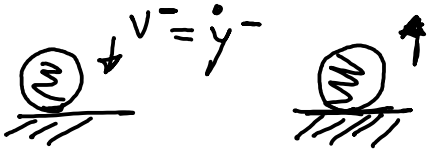
① Free Fall



$$\ddot{y} = -g \quad \text{—(1)}$$

② Bounce

$\dot{y}^-$ → velocity before bounce



$\dot{y}^+$ → velocity after bounce

Law of restitution:

e = co-efficient of restitution

$$-e = \frac{\dot{y}^+}{\dot{y}^-} \qquad e < 1 \qquad \dot{y}^+ = -e\dot{y}^- \quad \text{—(2)}$$

$e = 0 \Rightarrow \dot{y}^+ = 0$ Plastic collision

$e = 1 \Rightarrow \dot{y}^+ = -\dot{y}^-$ Elastic collision

$0 \leq e < 1$ → in real-world

Simulate in MATLAB

① function one bounce

② Free fall: $\ddot{y} = -g$

ode4, ode45, .. (time-based)

We need to stop the integration when $y=0$ time is unknown

ode45 → options (argument)

options = odeset ('AbsTol', 1e-9, 'Event', @detect_ground)