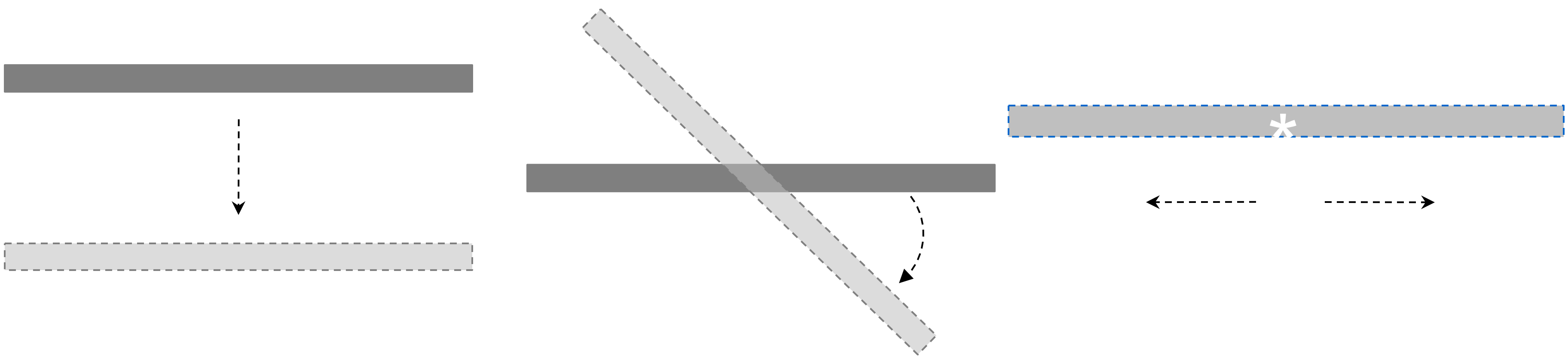
Hopper Physics

Olin College of Engineering

Three types of motion

Rigid Body Motion — **Deformation**

Translation | Rotation | Vibration



As a designer...

“Run the movie in your head”

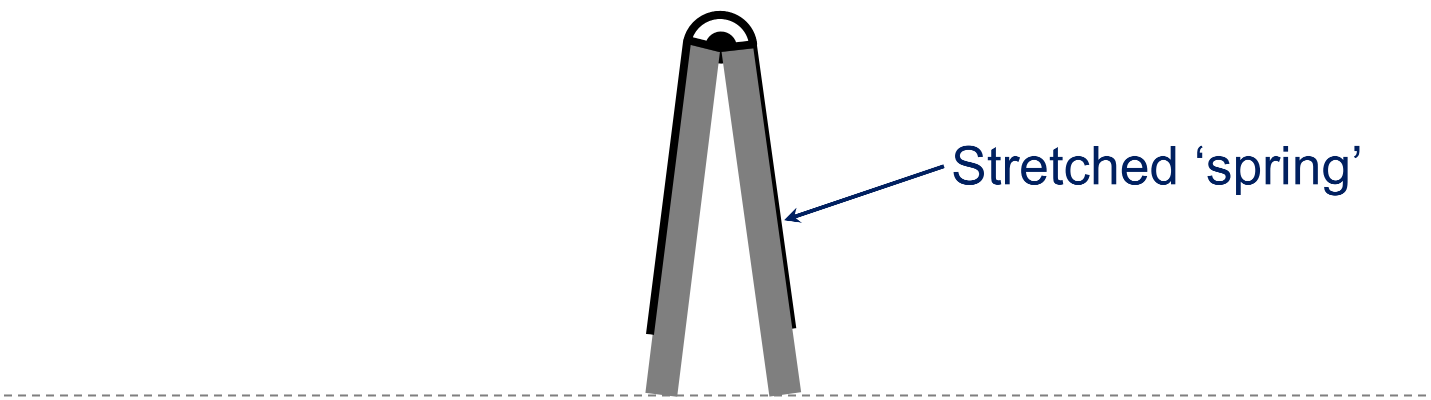
Start by visualizing where each hopper part and the overall center of mass (CM) are located just after time $t=0$.

Then start going forward in time.

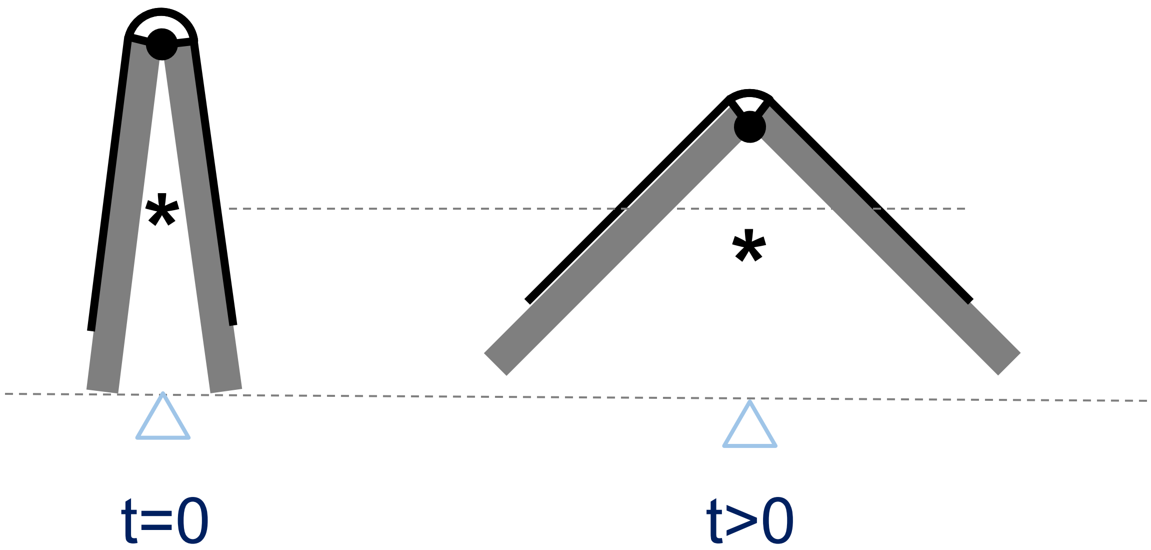
Checklist for analyzing hopper motion

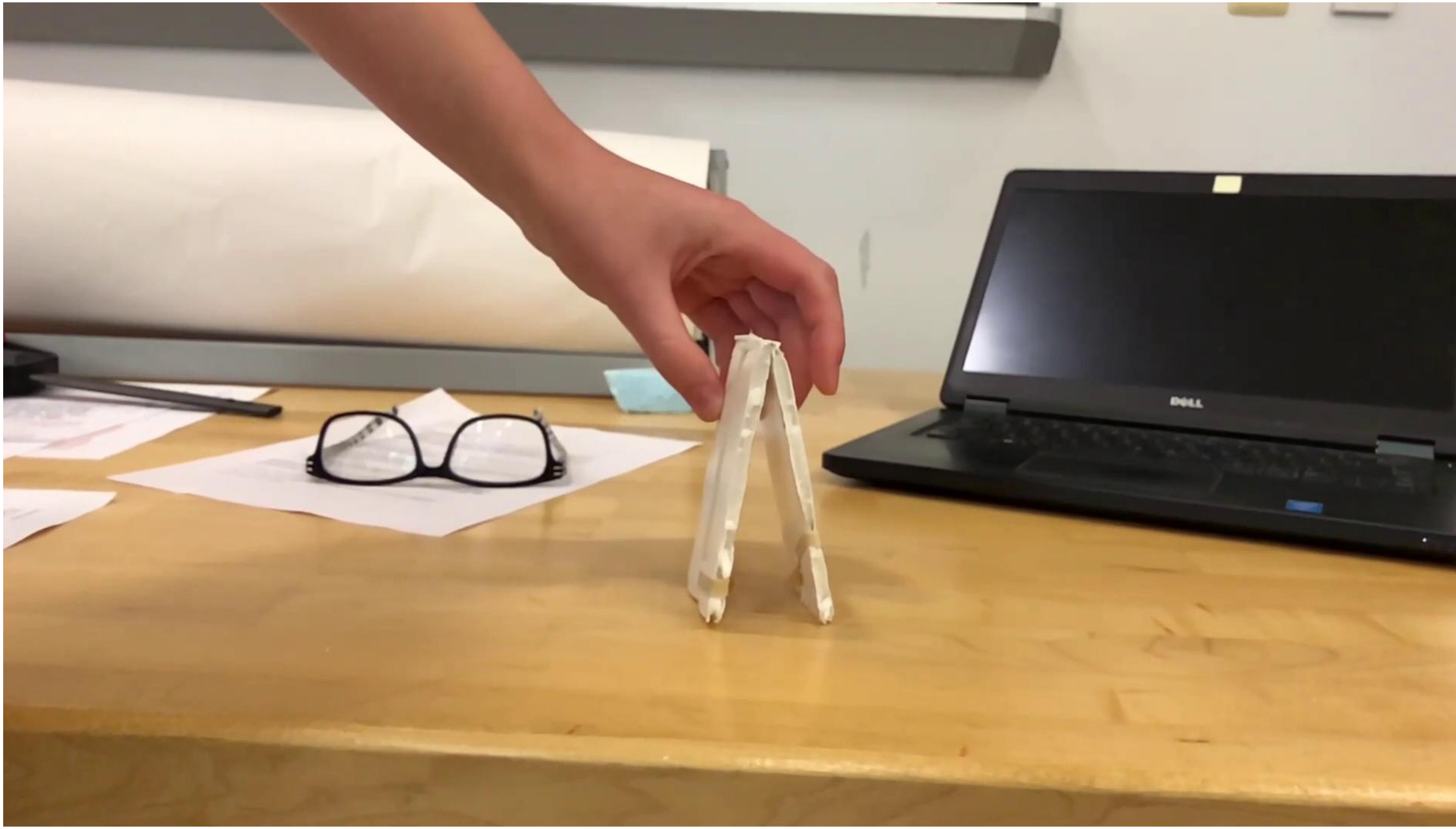
1. The hopper system: Estimating the system's center of mass (CM) by considering its mass distribution.
2. Locate the origin and direction of all external forces on the CM of the hopper system, including the gravitational, normal, frictional, and elastic forces. What is the origin and direction of the elastic/spring forces relative to the CM?
3. Consider the trigger location and alignment with the CM of the system.
4. How does the *net* external force on the system affect the motion of the CM? Considering net force on the system, visualize how the position of the CM changes after the trigger is released.

Where does it go?

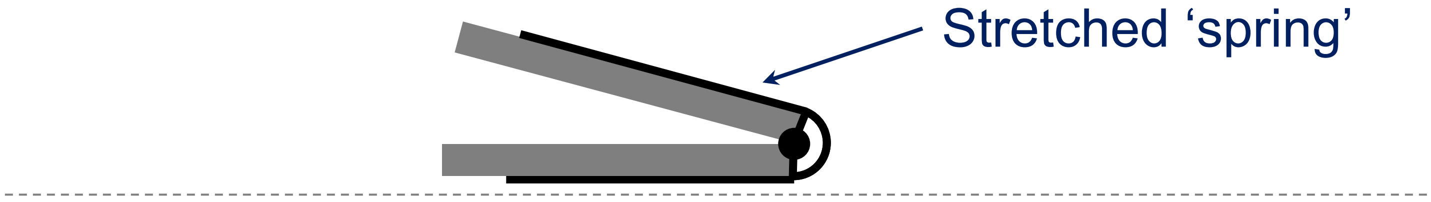


Make your prediction…

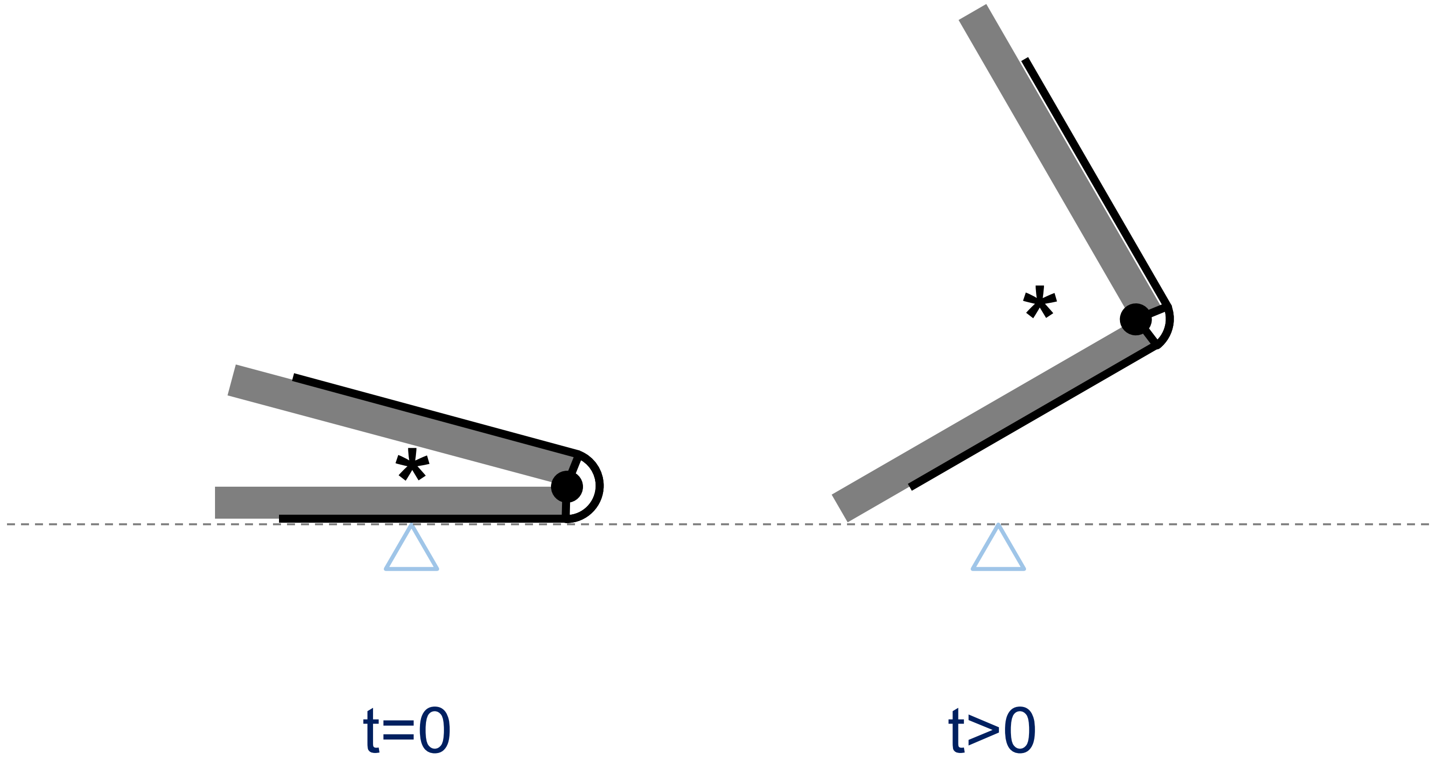

*
*
t=0
t>0

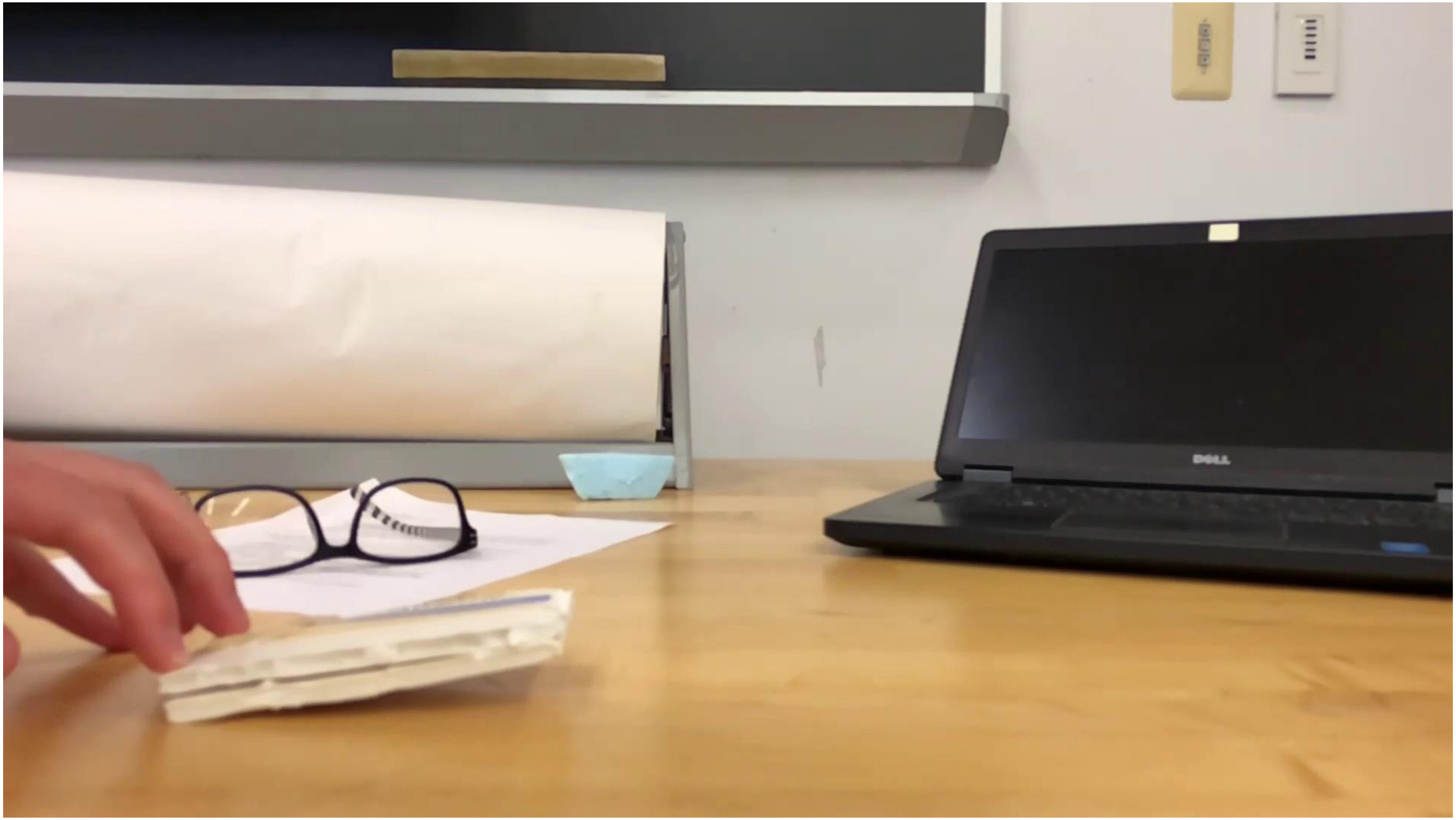

DELL

Where does it go?

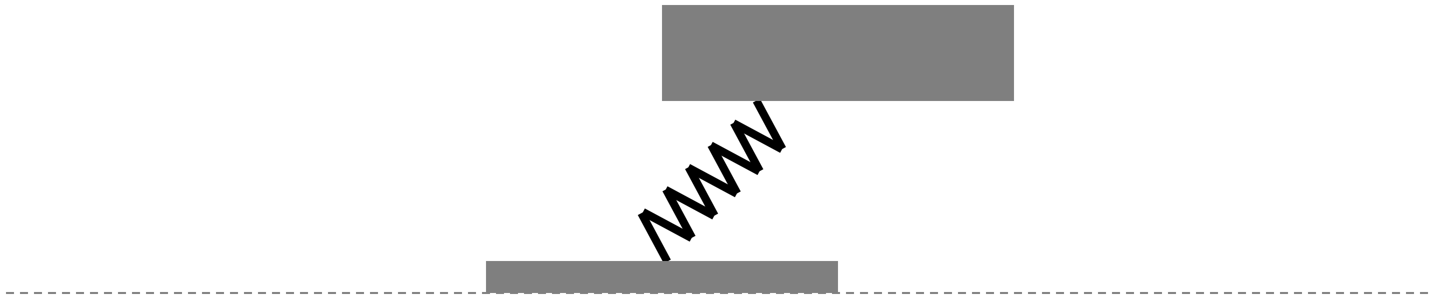


Make your prediction…

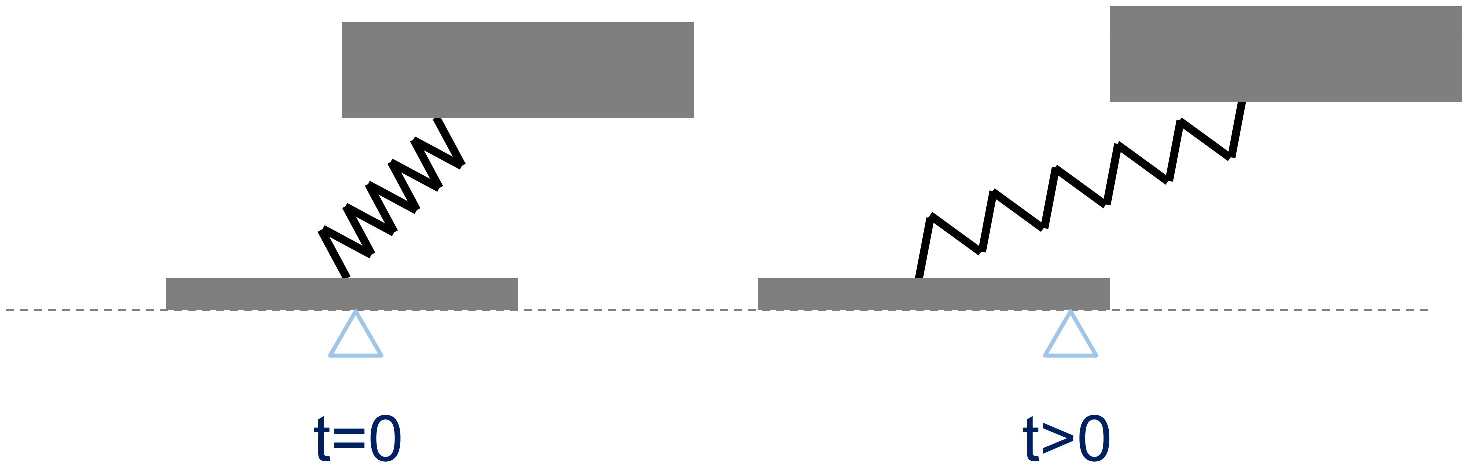

*
*
t=0
t>0

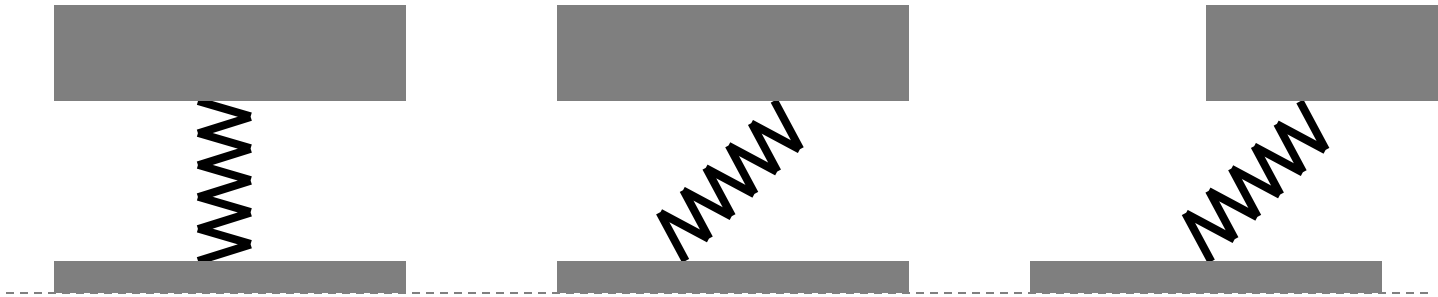

DELL

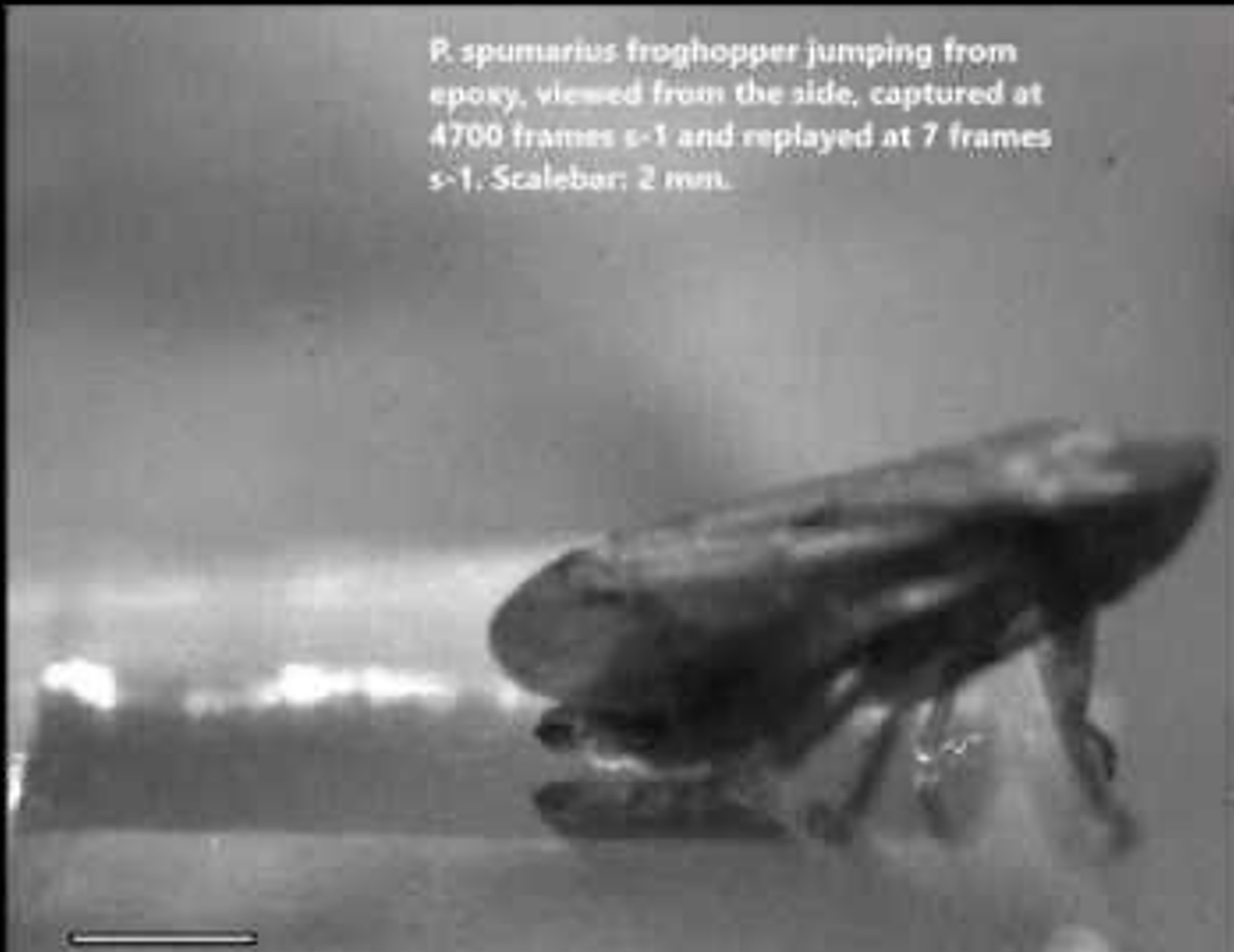
Where does it go?



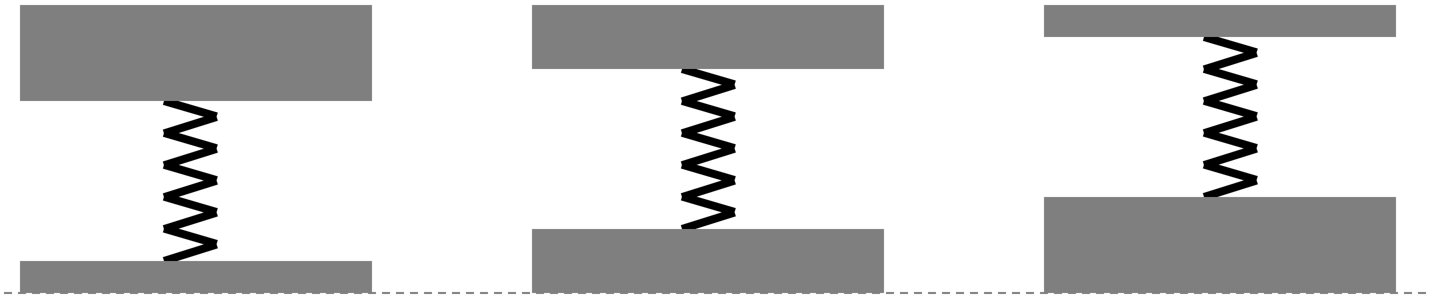
Make your prediction…


t=0
t>0




P. spumarius froghopper jumping from epoxy, viewed from the side, captured at 4700 frames s-1 and replayed at 7 frames s-1. Scalebar: 2 mm.

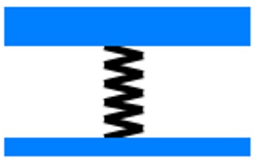
Which one jumps highest?



Make your prediction…

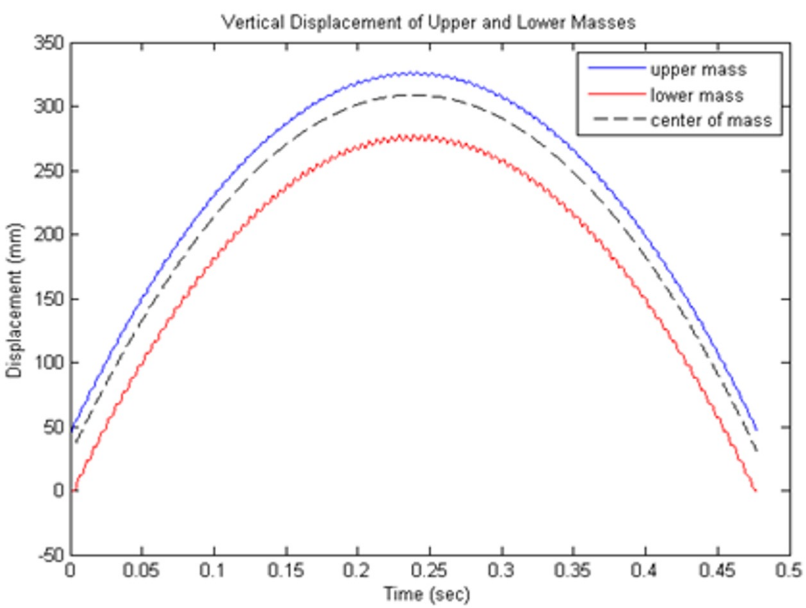
And the simulation says …

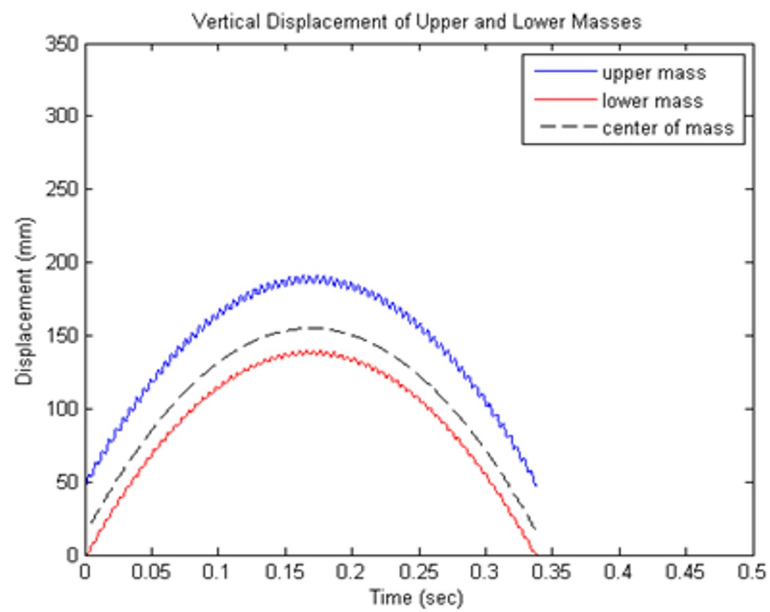
m_{upper} = 20 g
m_{lower} = 10 g



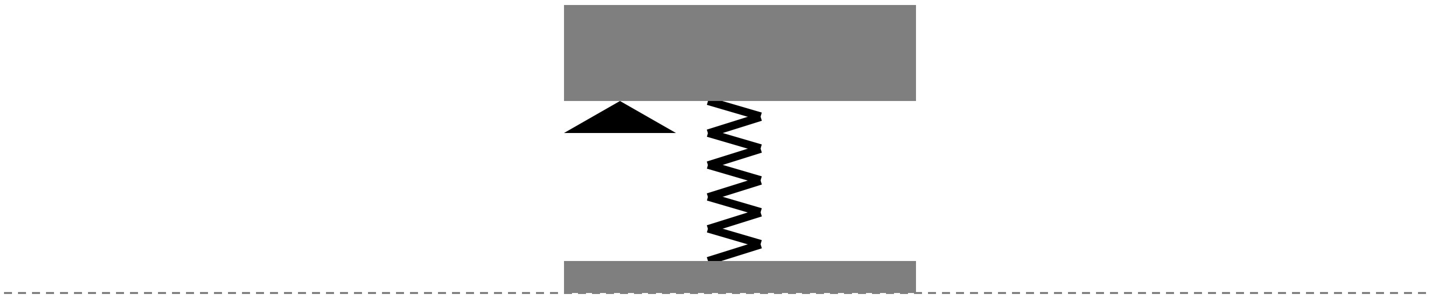
k = 9810 N/m
L_0 = 50 mm
d = 5 mm

m_{upper} = 10 g
m_{lower} = 20 g





What happens?



Make your prediction…

Which trigger releases first?

Make your prediction…