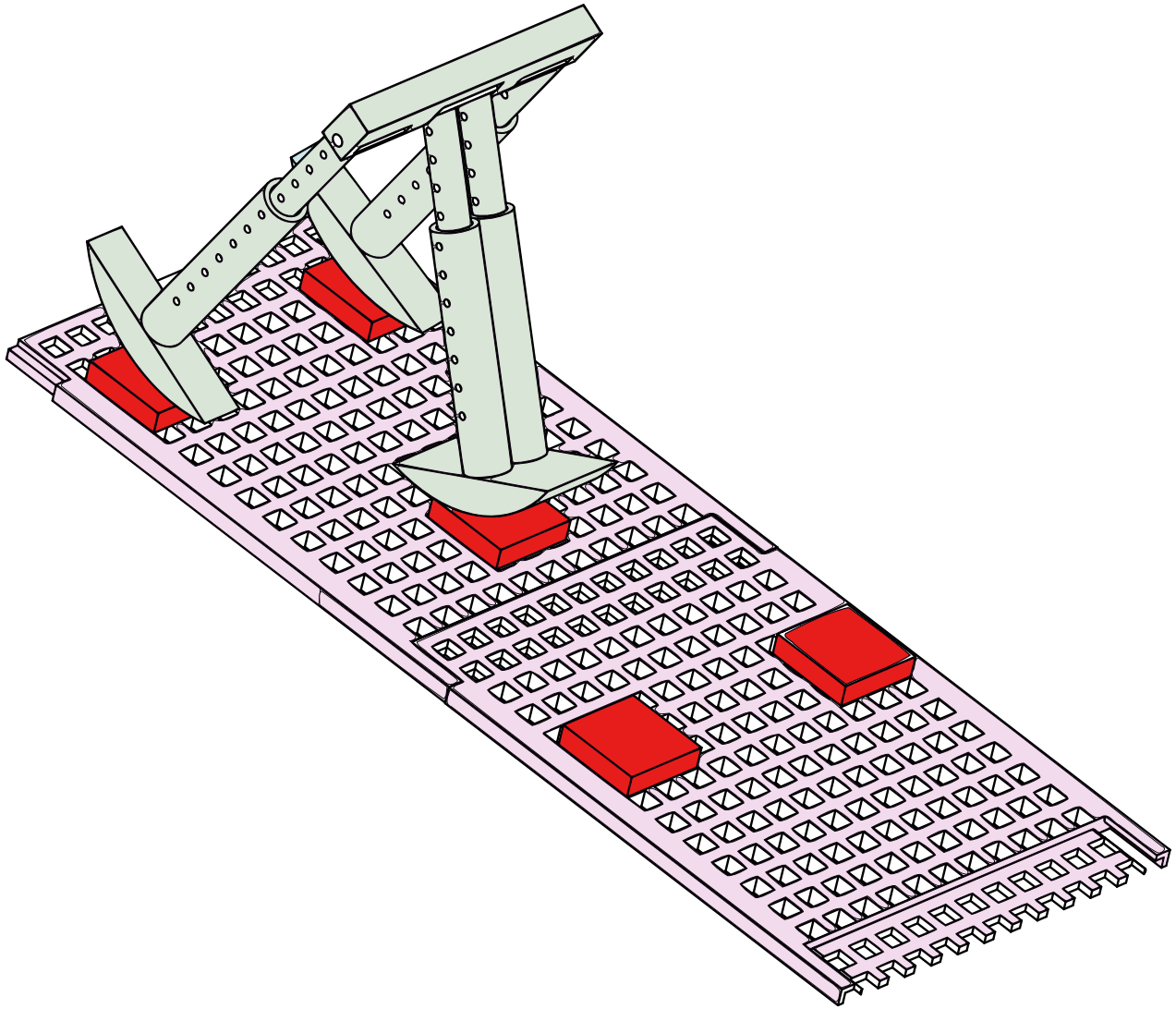
Locomotion: Passive Dynamic Walker



National Biomechanics Day

CMU

Ravesh Sukhnandan

Session Overview

Introduction: 5 mins

Building Your Own Walker(!): 10-15 mins

Testing Walkers: 10-15 mins

Wrap-up: 2 mins

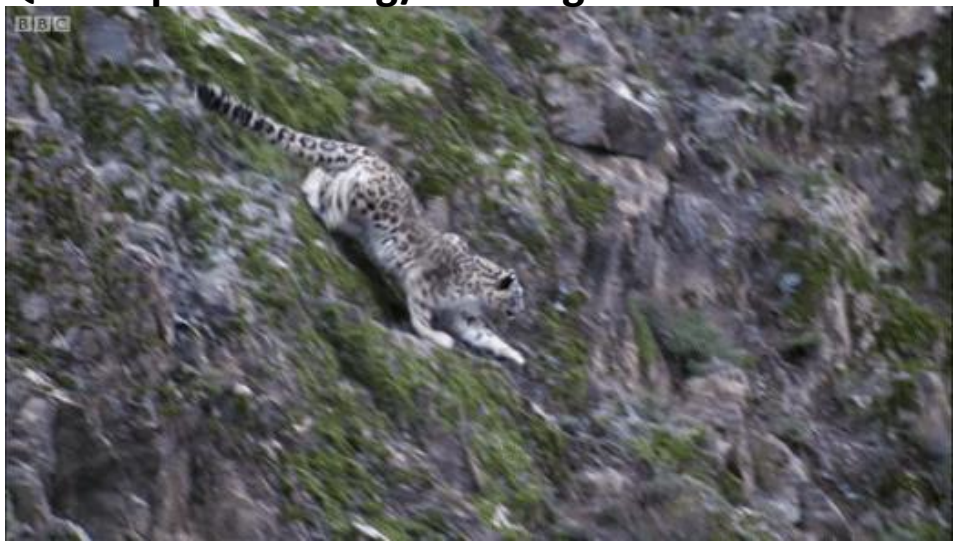
What is locomotion?

Swimming

Crawling

Flight

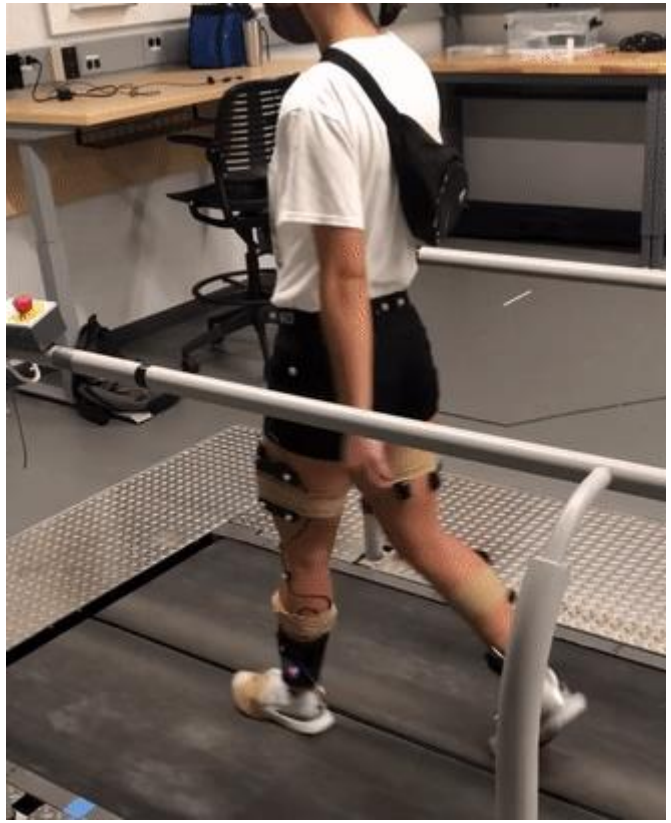
Quadruped Walking/Running



What is locomotion?

"...any of a variety of movements among animals that results in progression from one place to another" [5]

Humans: Bipedal Walking



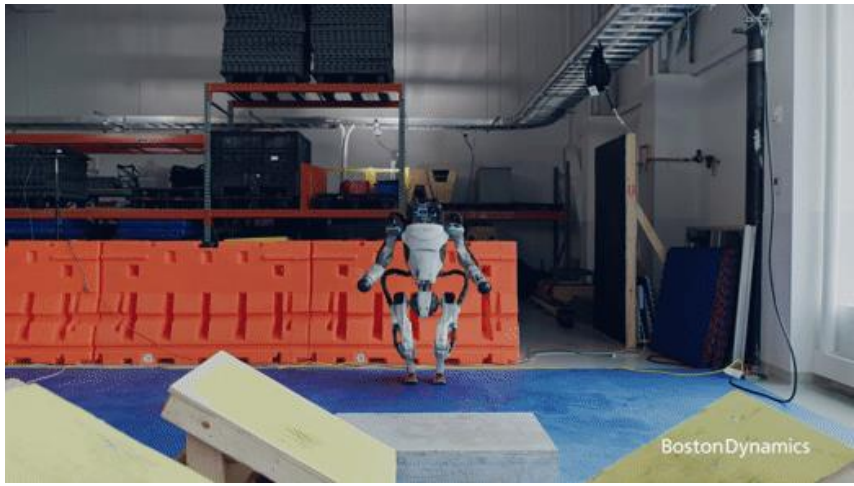
(**Credit**: Owen Pearl and Human Biomechanics Lab)

Why should we study locomotion?

Sports and Rehabilitation

Exoskeletons

Better Robots

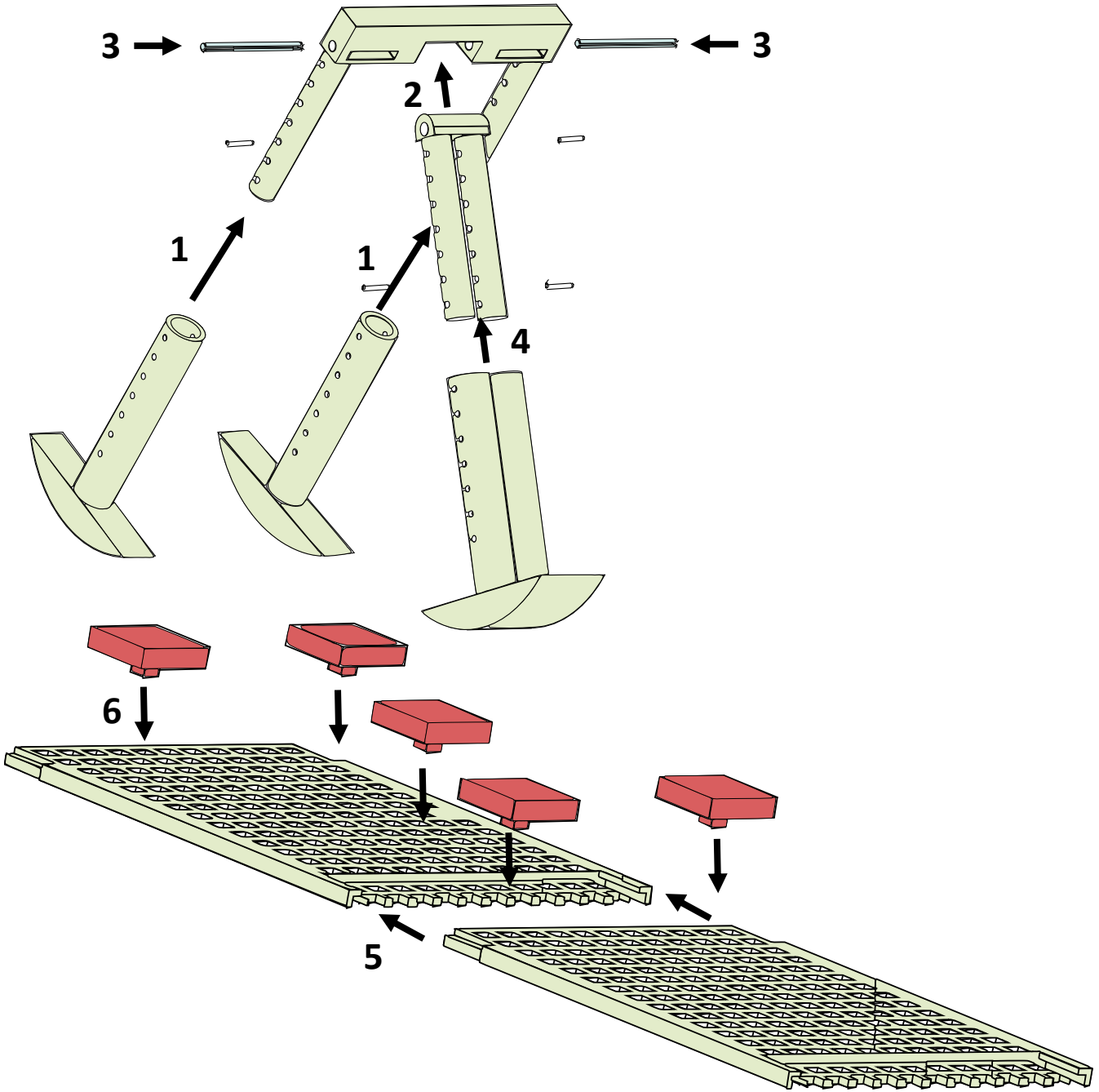


You must (passively dynamically) walk before you can run

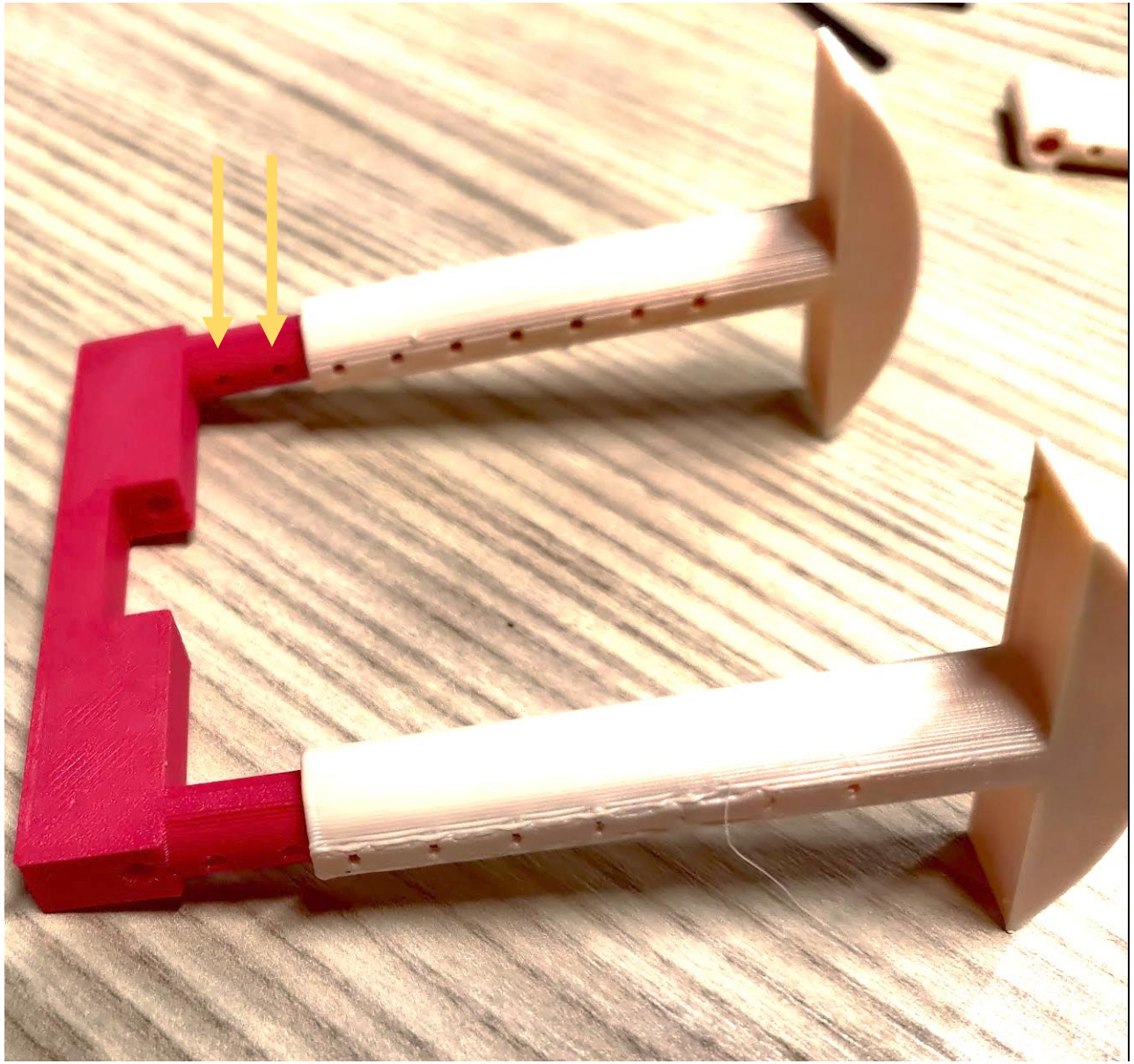
What we will build today:

Building your walker!

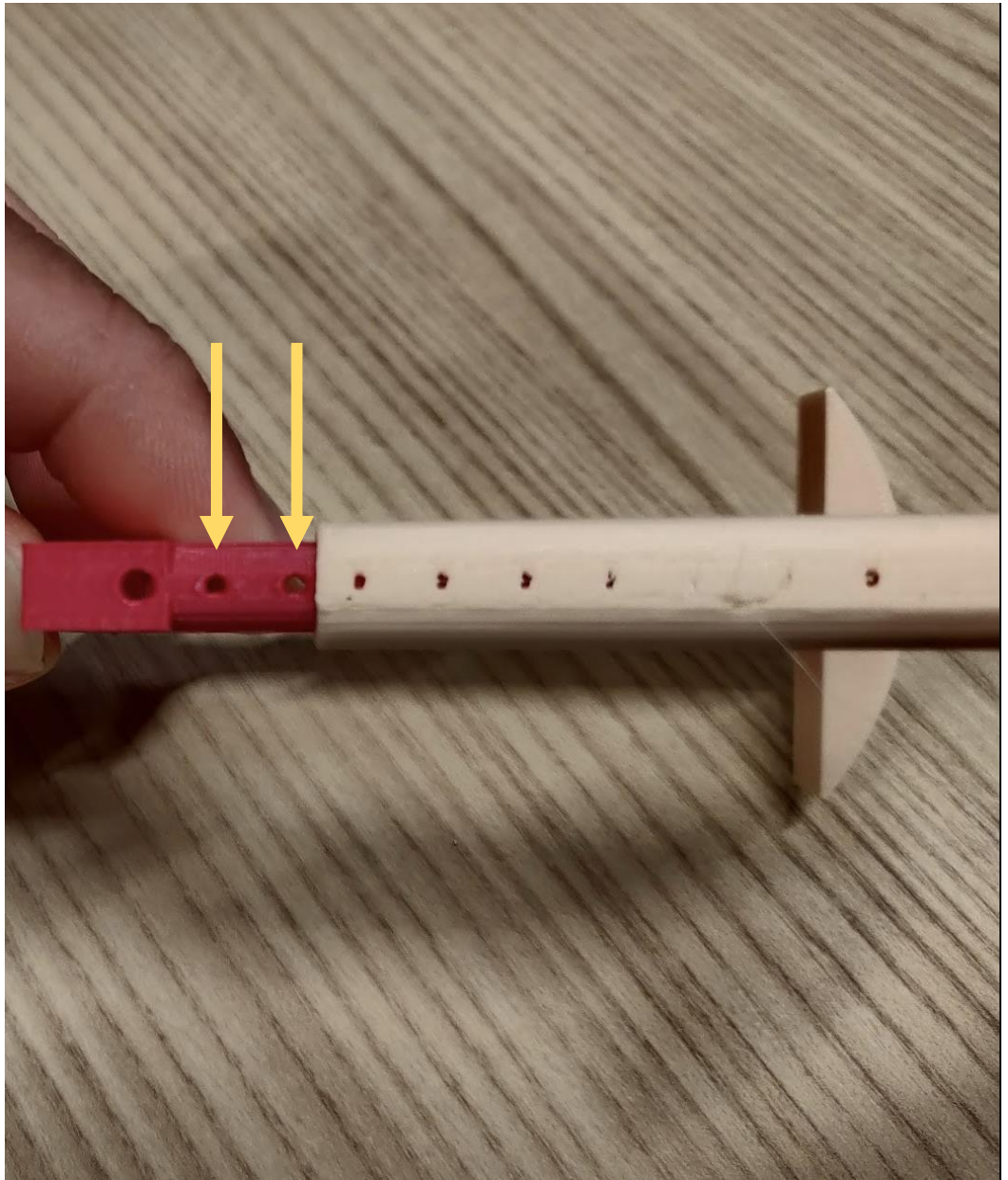
Kit Review



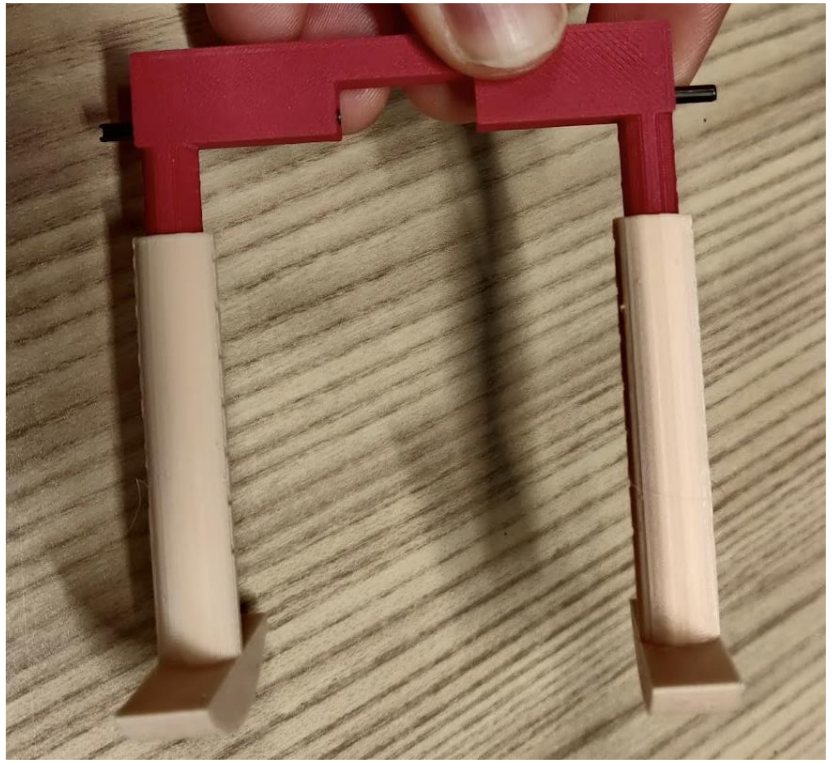
Slide the outer legs over the inner ones until there are two holes left



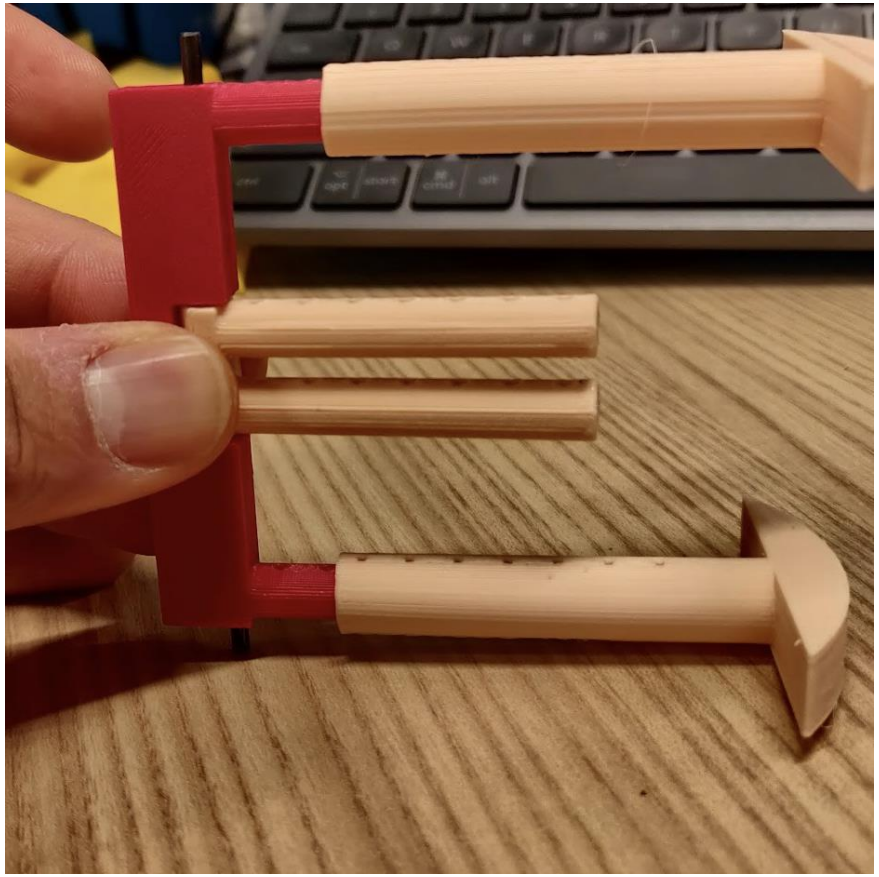
Slide the outer legs over the inner ones until there are two holes left



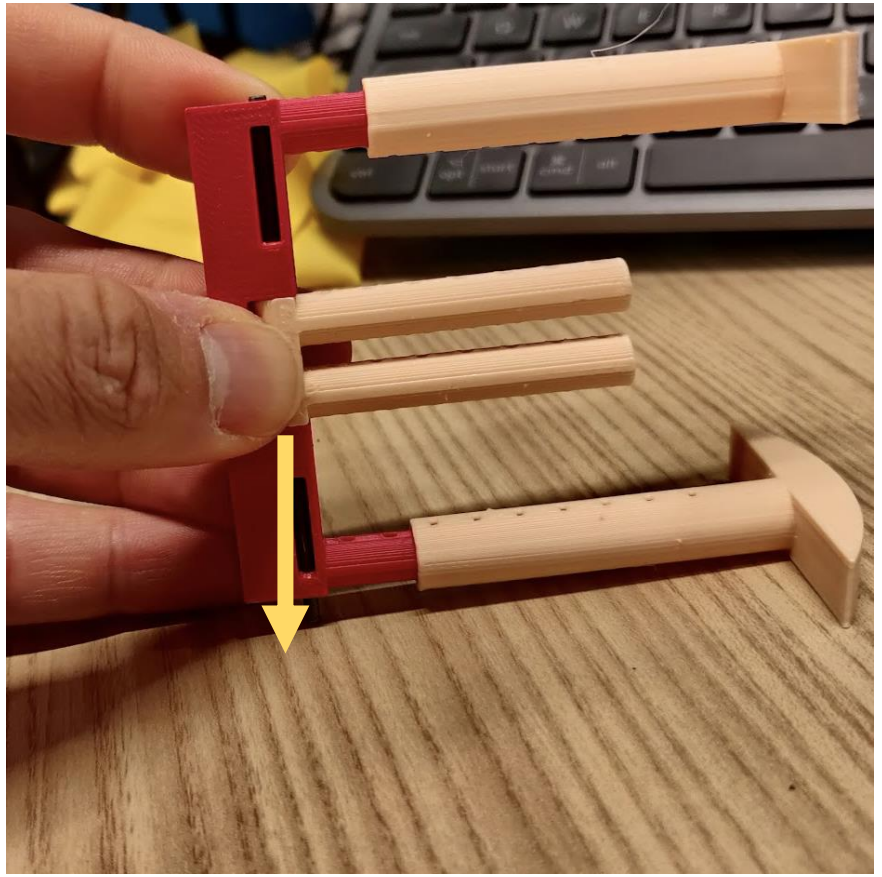
We will now do the inner leg



Position the inner leg as shown

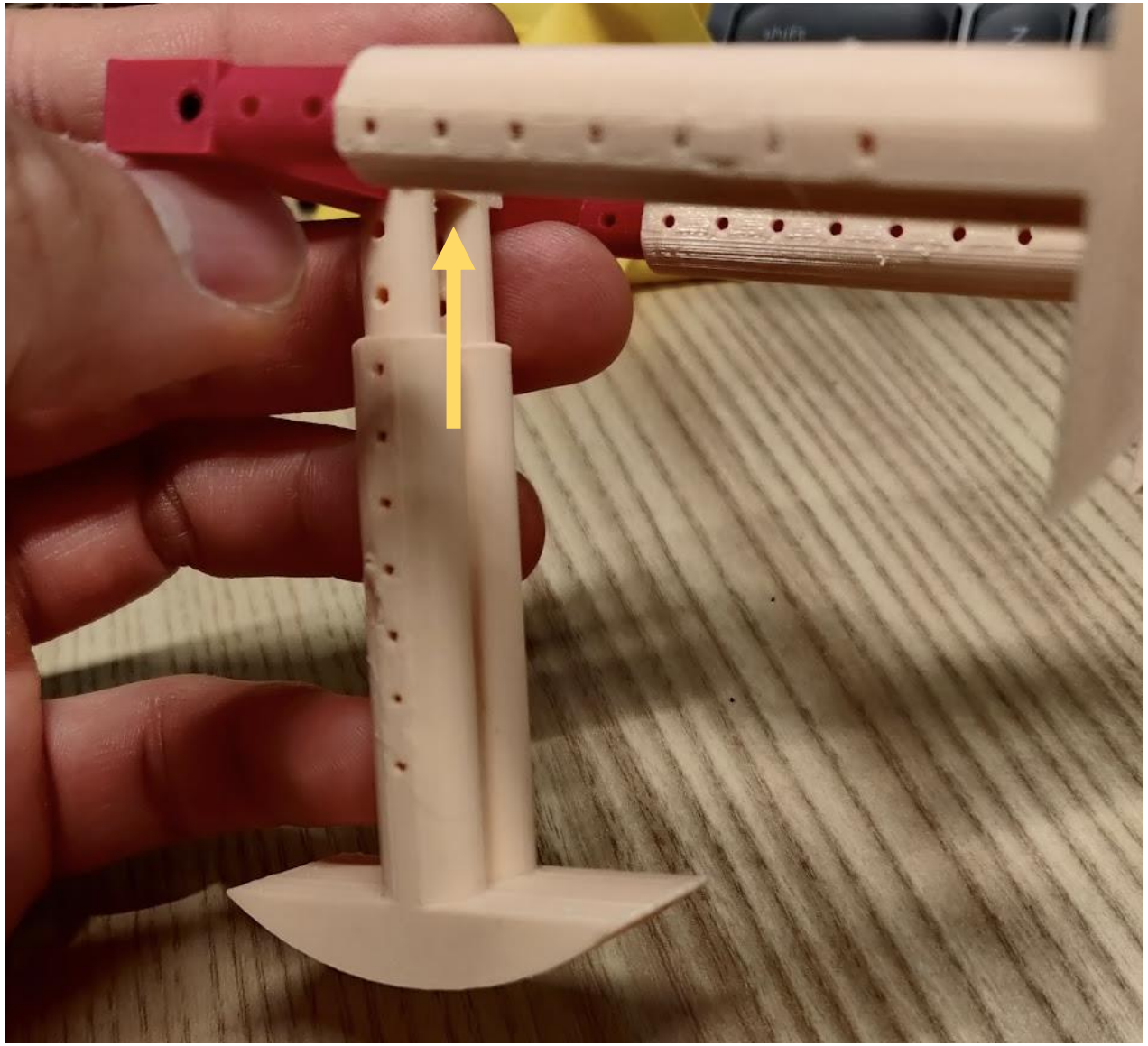


Then press down on the table to push the pins in place

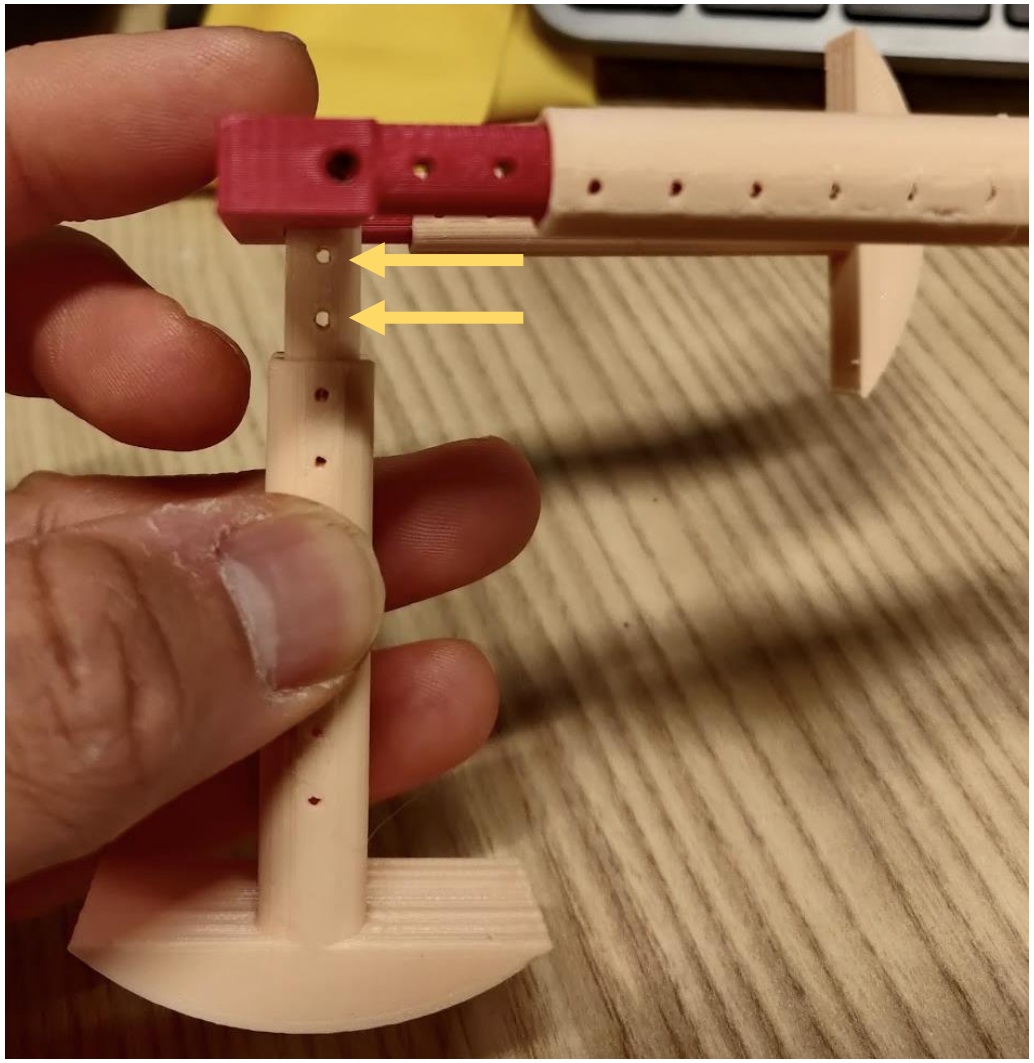


You should have something that looks like this now

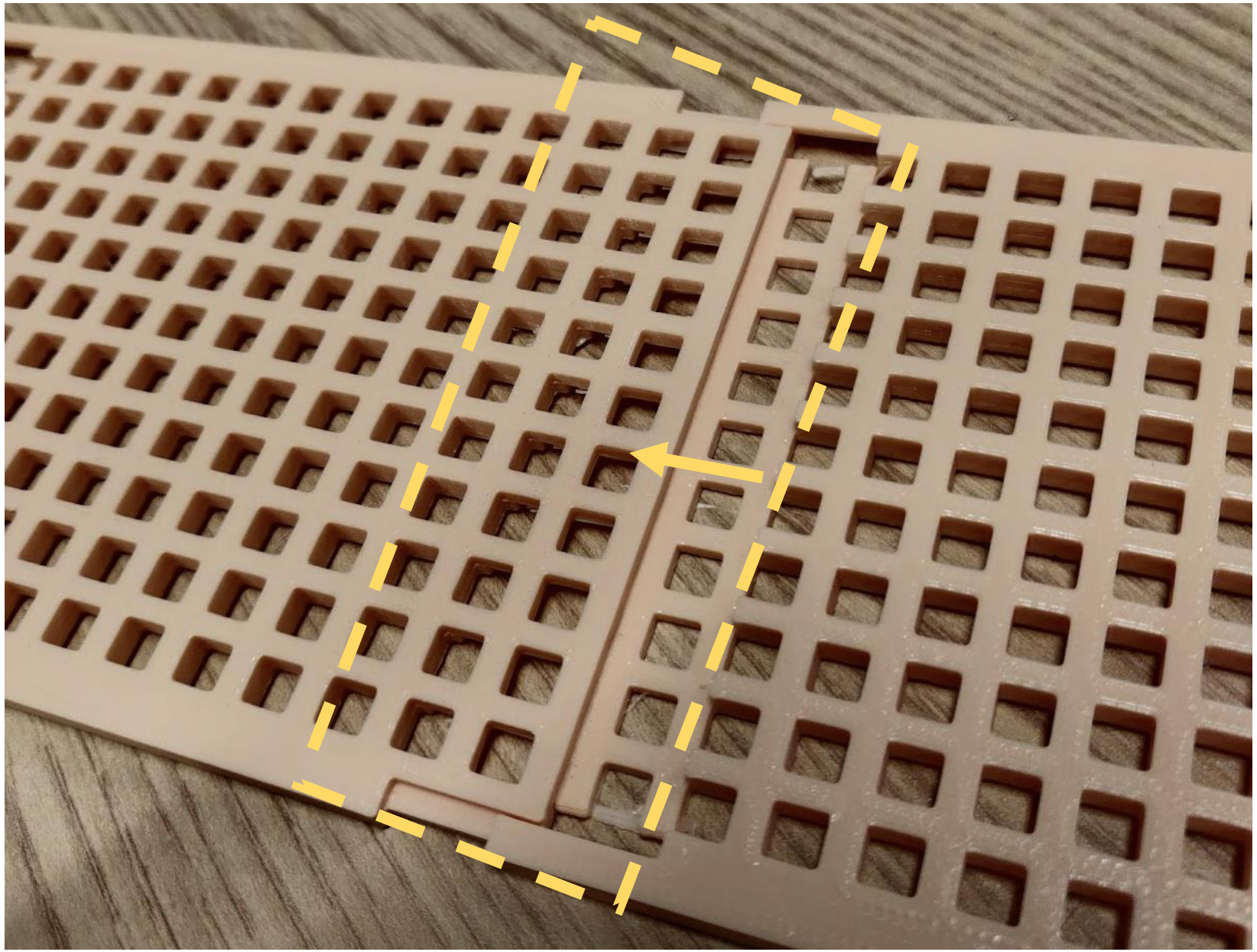
Slide the double leg unto the inner leg until you see two holes



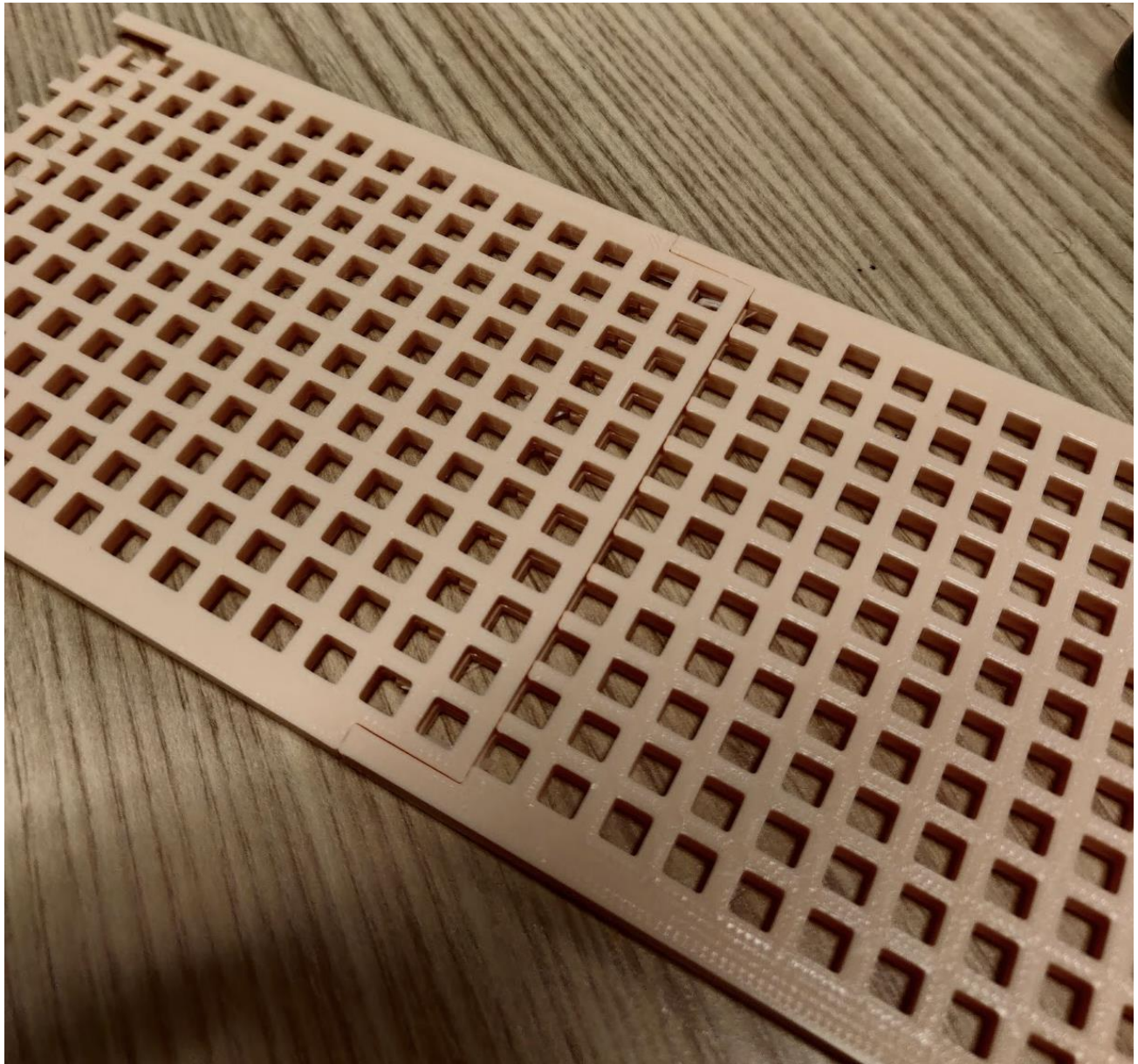
Slide the double leg unto the inner leg until you see two holes



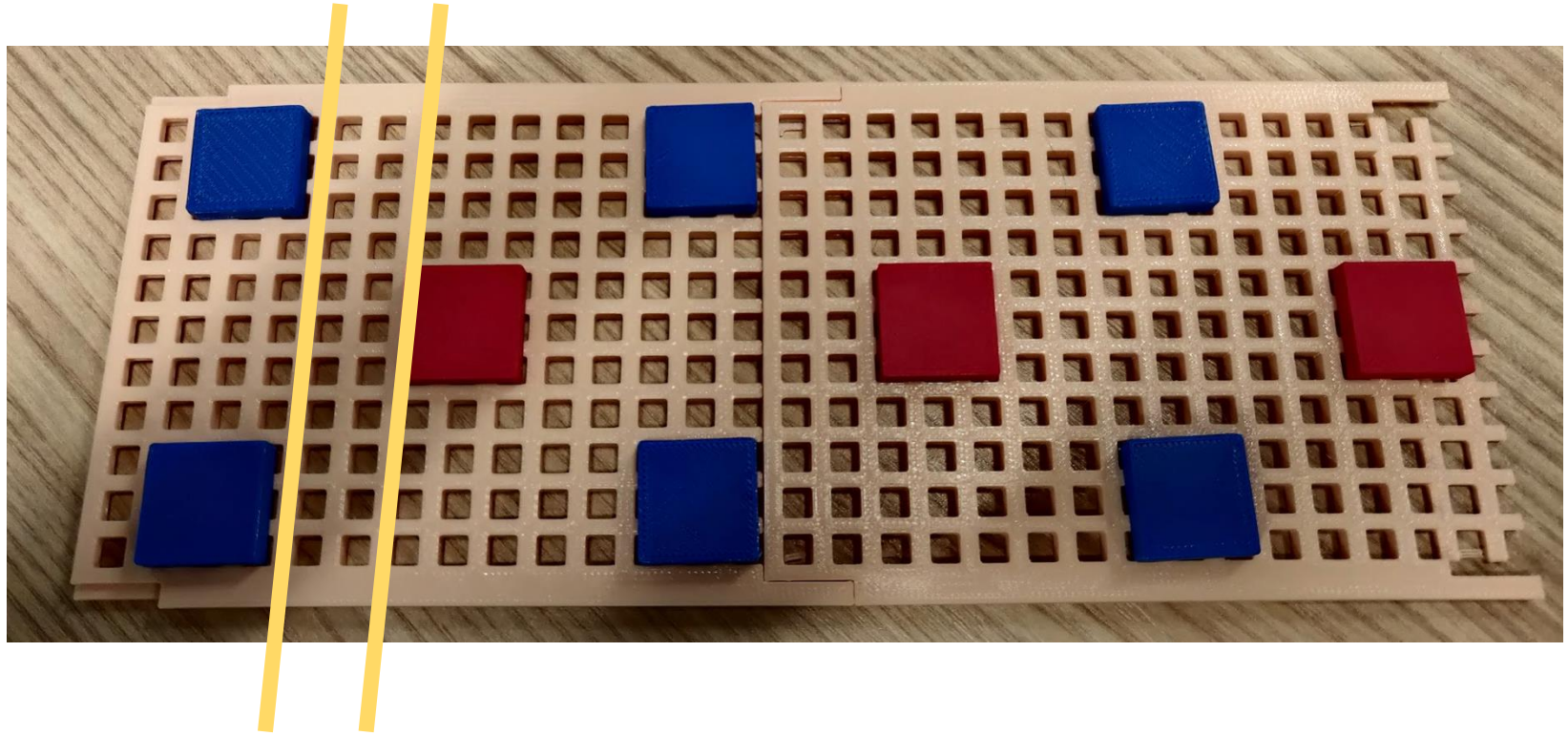
Now we’ll assemble the ramp. Watch carefully



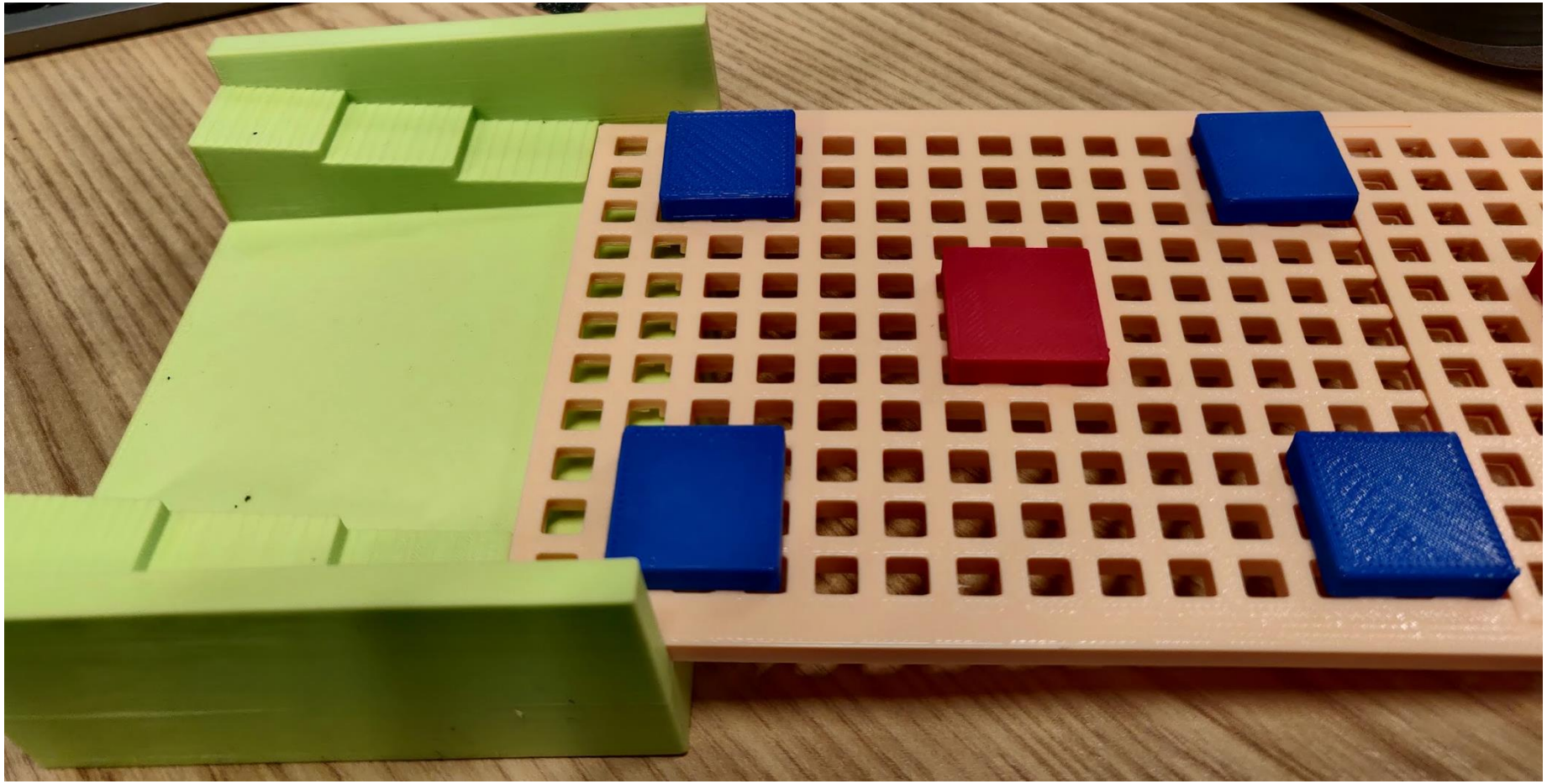
Your ramp should look like this:



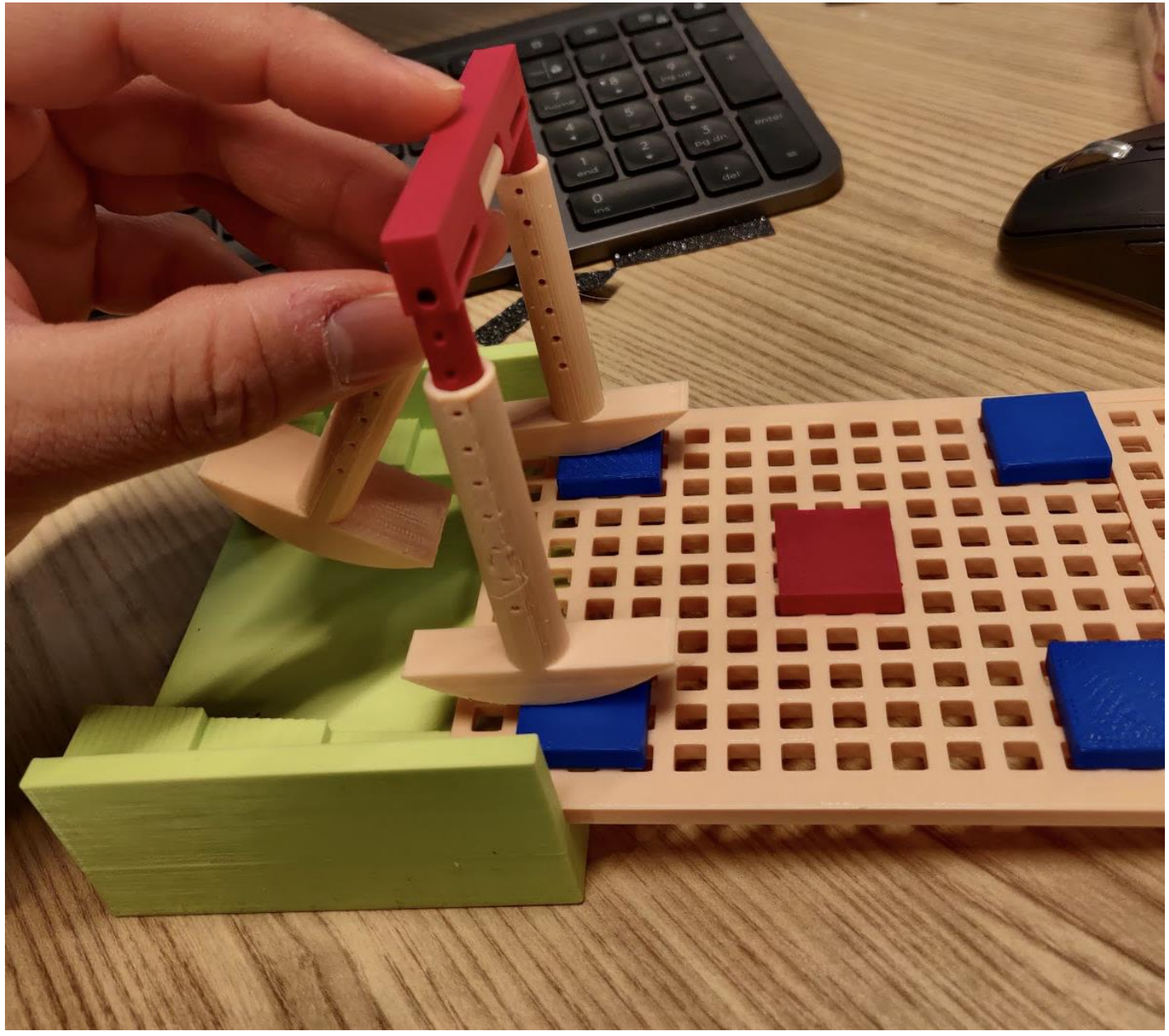
Place the pads as shown in the picture below.
Notice there are two empty rows between each pad!



Now let’s place the ramp on the lowest level of the incline

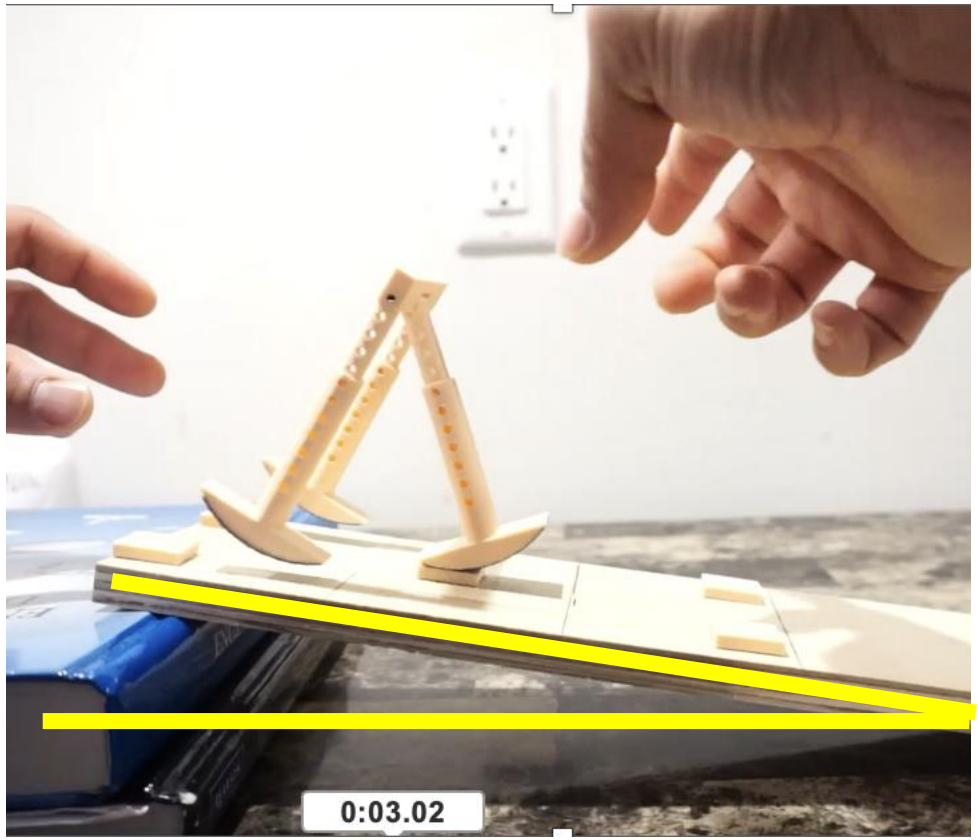


Now you are ready to see if your walker can walk!



A few questions

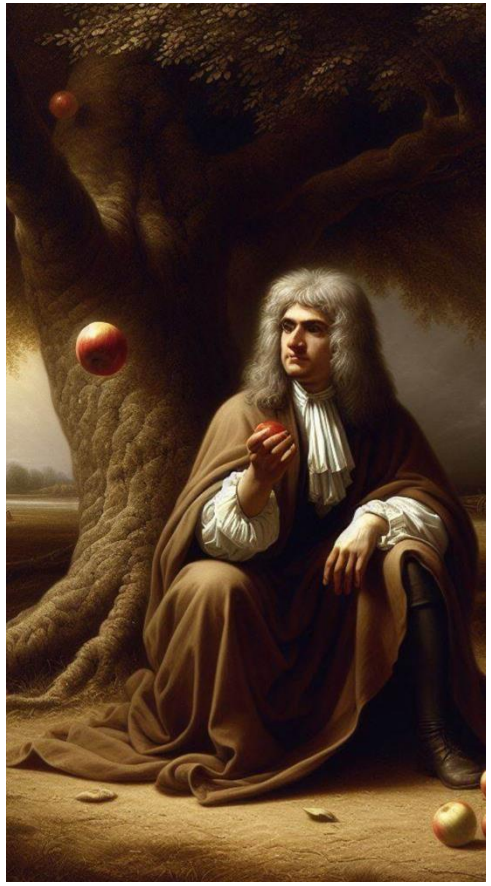
What force is driving the walker down the ramp?



Hint: Is it easier to go down a hill, or up a hill?

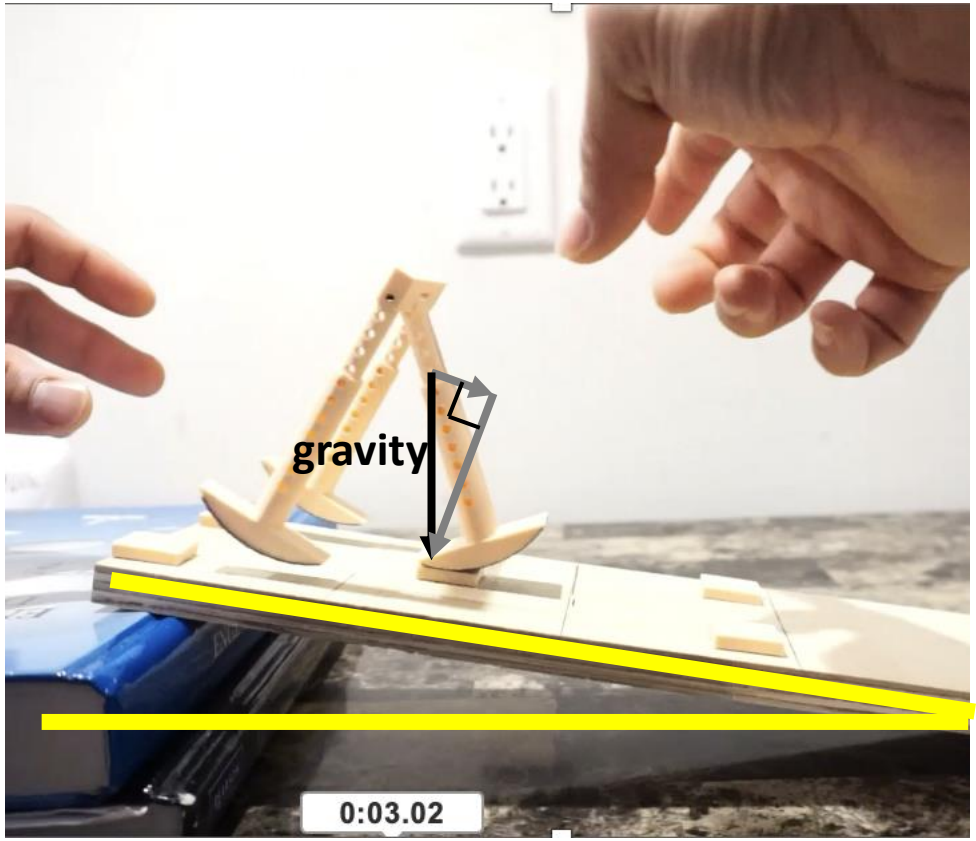
What force is driving the walker down the ramp?

ANS: Gravity!



Isaac Newton and his famous apple (AI generated)

What force is driving the walker down the ramp?

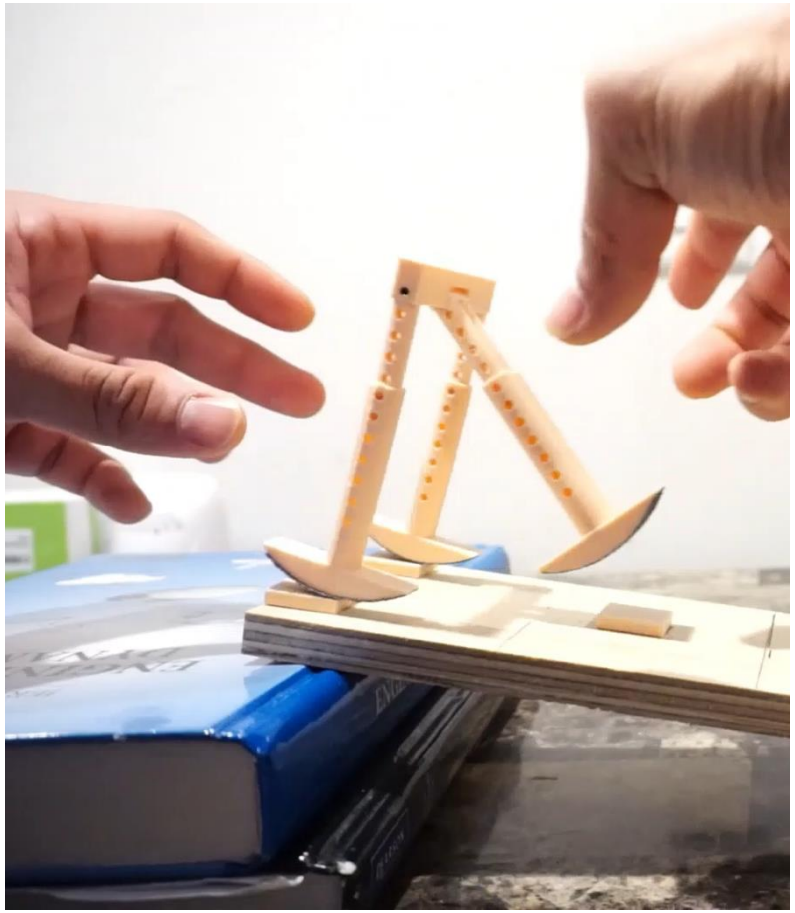


Exercise 1

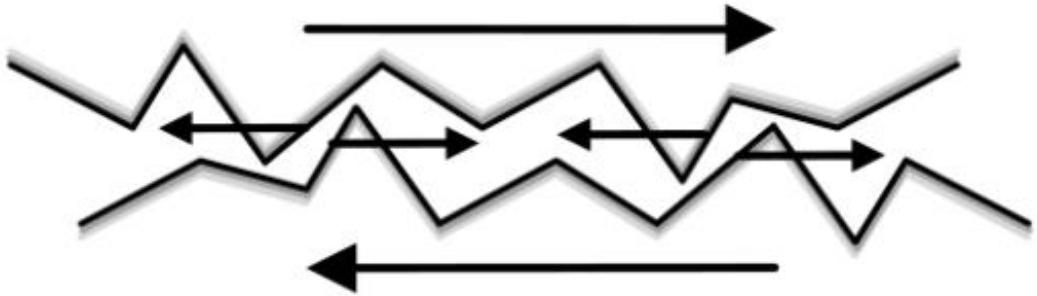
Is your walker sliding? Let’s take a closer look at the contact

Have you ever slipped on ice?

Q: What is the name of the force that allows us to roll over our foot without slipping?



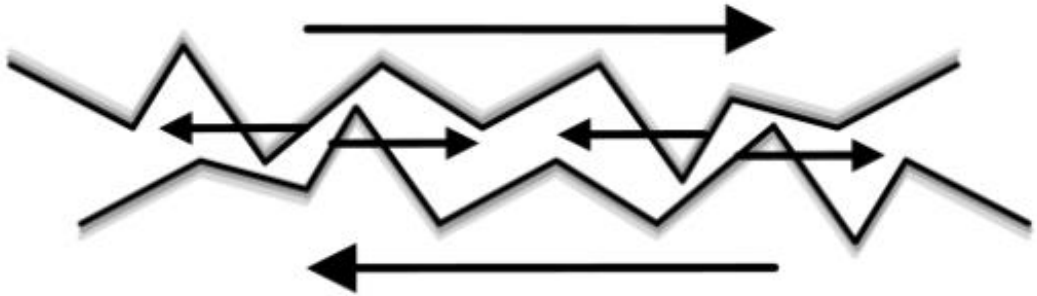
ANS: Friction!



Microstructure of two surfaces in contact.

Shoe sole of a hiking boot

ANS: Friction!



Microstructure of two surfaces in contact.

Car wheel tire

How can we increase friction on our walkers?

HINT: You need something rough to the touch

Exercise 2

Attach the sandpaper strips to the feet of the walker

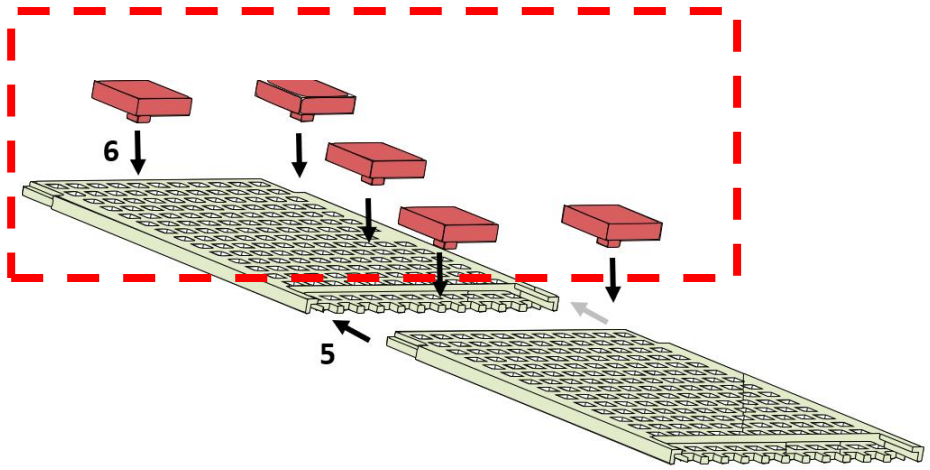
Your walker should now look like this

Now try your walker again!

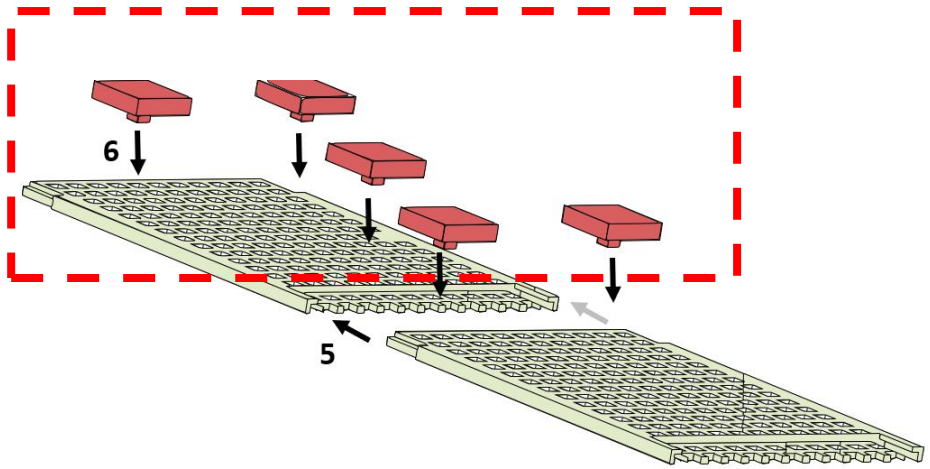
Is it still slipping, or can you get it to walk?

Exercise 3

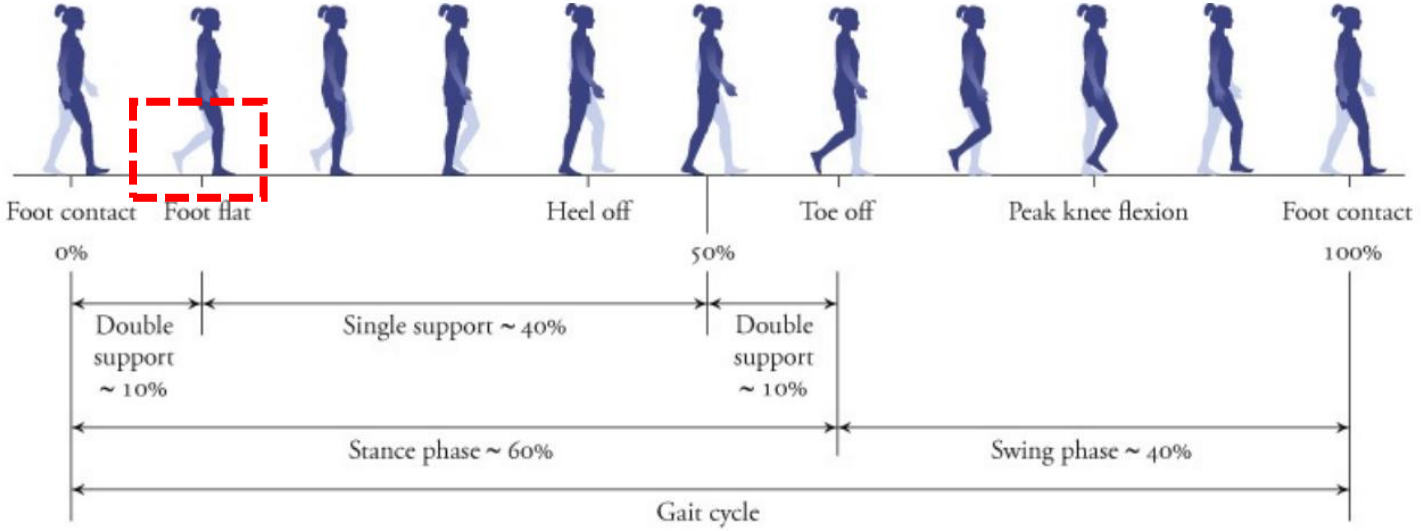
Why do we need these pads?



Why do we need these pads?



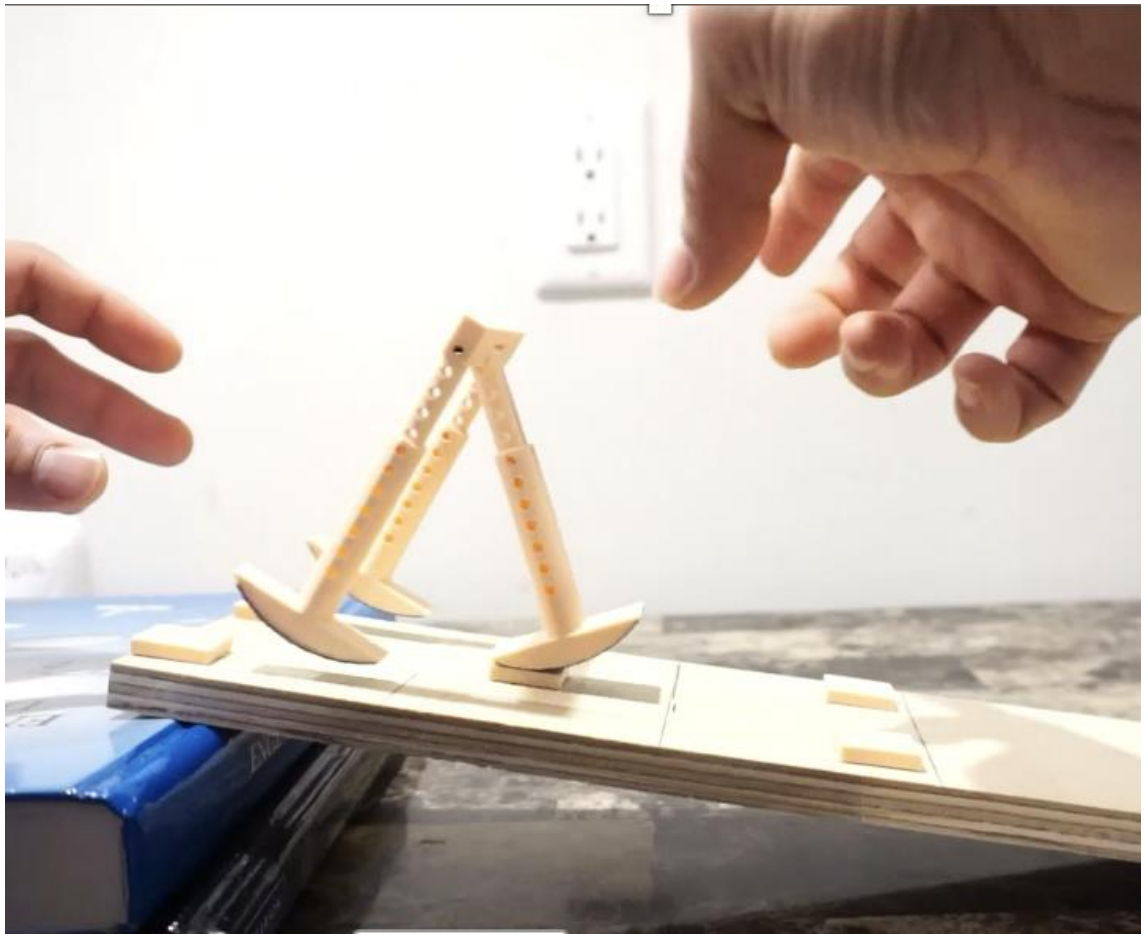
Because our walkers don't have knees!



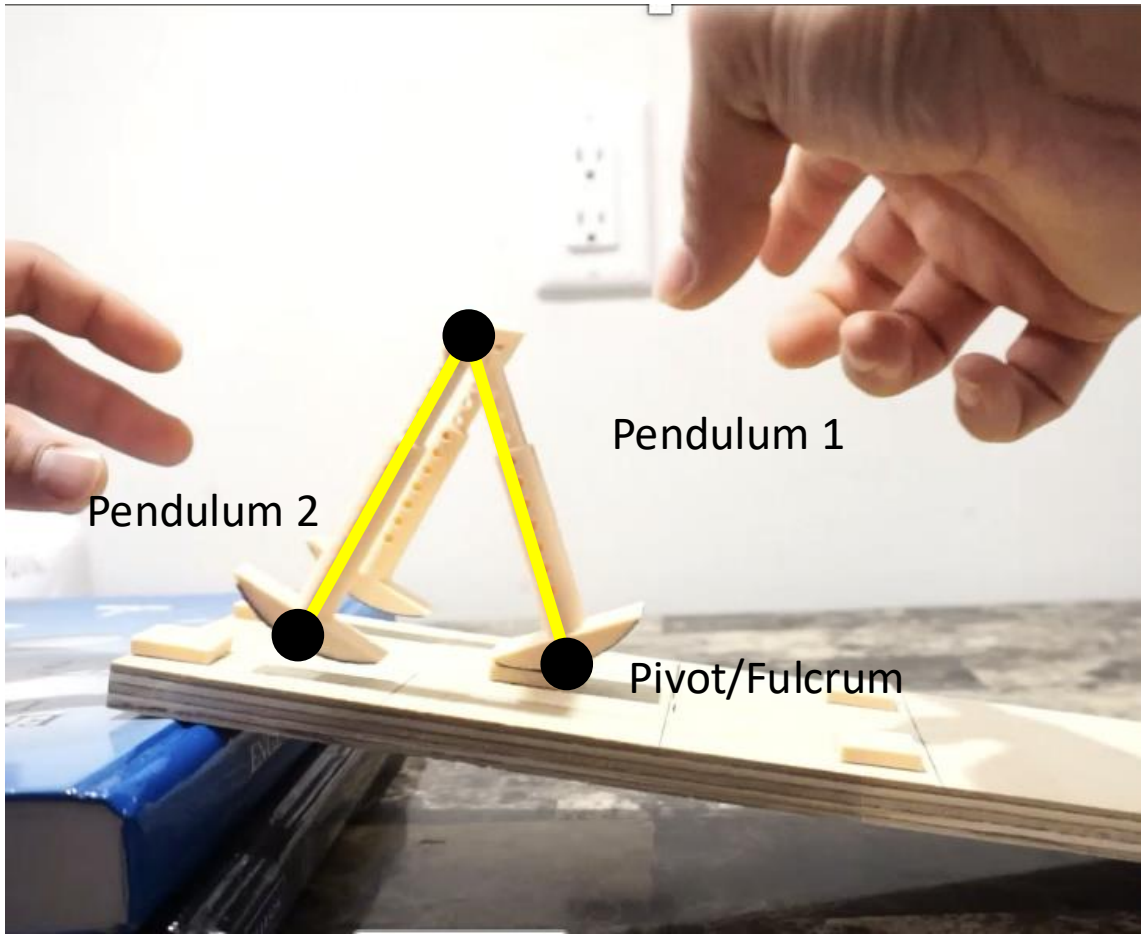
Exercise 4

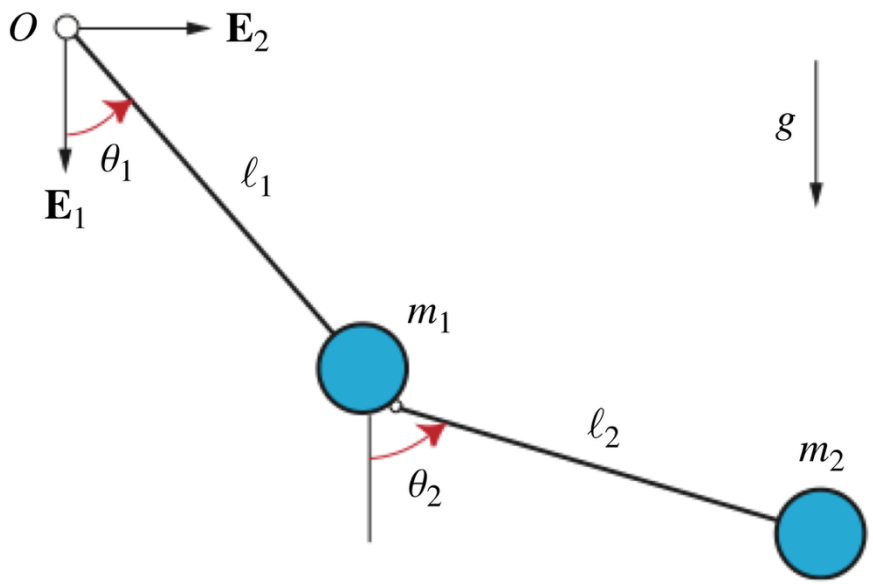
The robot is quite finicky to get it to walk right?

What does our walker look like?



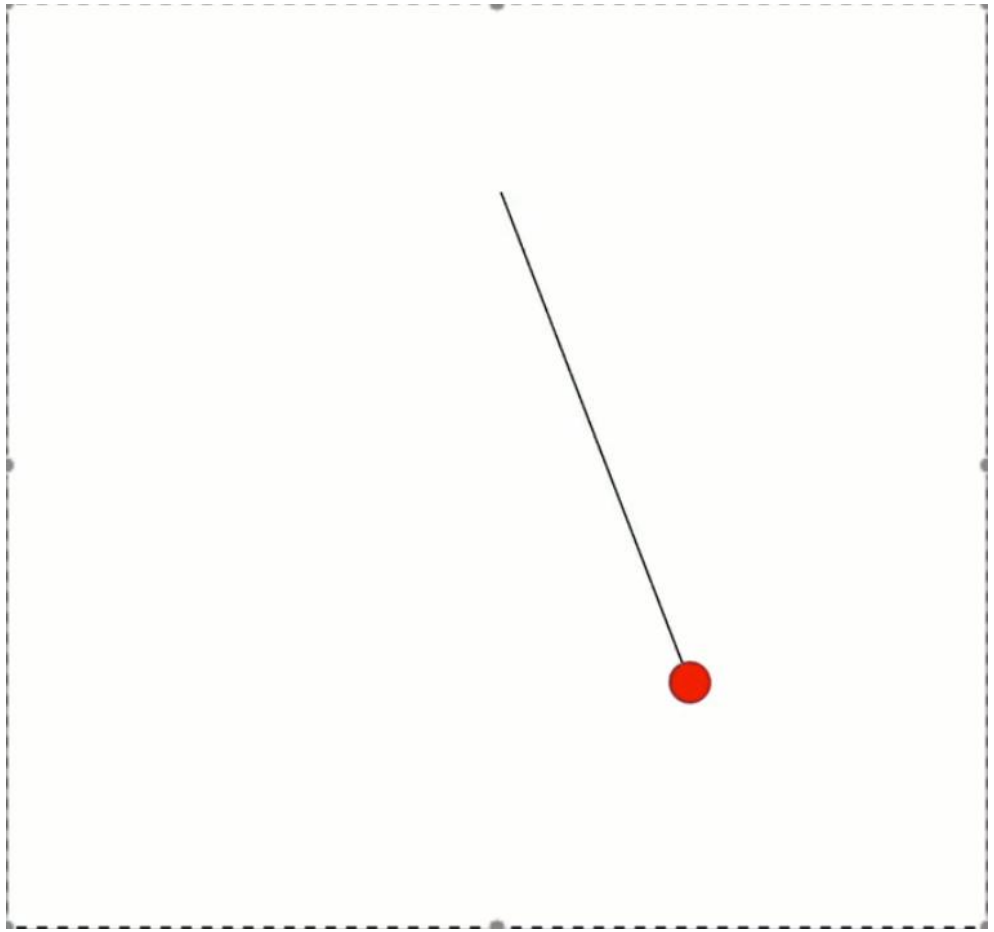
A double-pendulum!





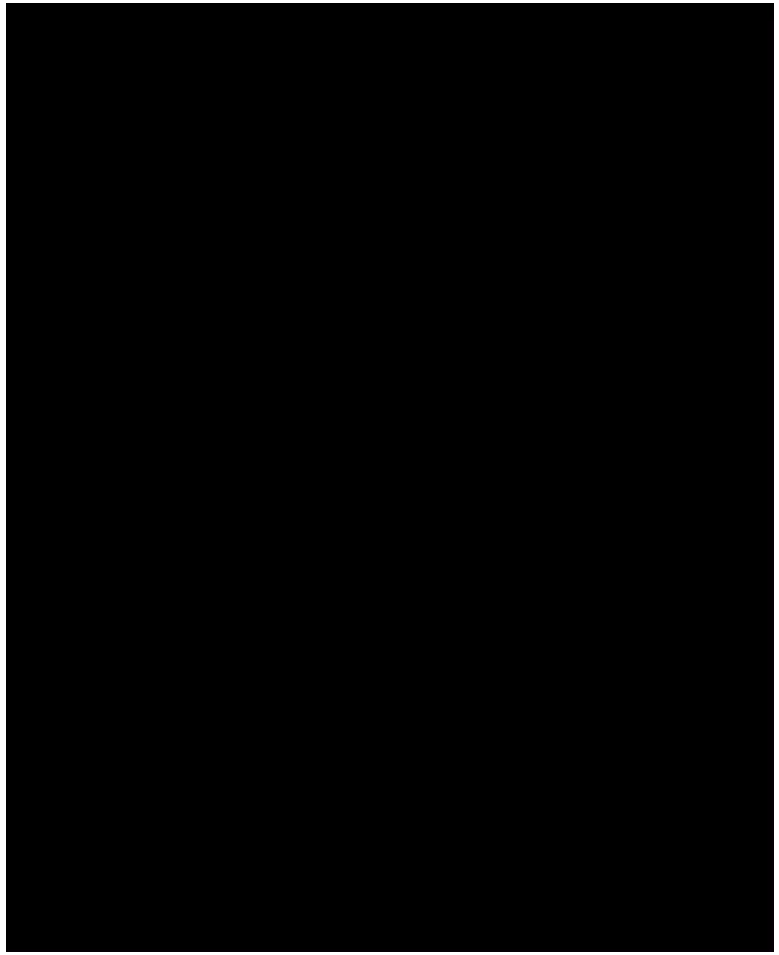
https://images.app.goo.gl/EpMktq4aGmTjRj5r9

A single pendulum is very repeatable …



https://youtube.com/shorts/pa-qsRhu_lo?si=LbhPddN85fBOHWgI

A double pendulum exhibits CHAOS



https://youtube.com/shorts/VIOdvQvG_-s?si=1ptoGl7115U_eGo9

Chaos: A small change in the start, leads to big changes in how the system evolves with time

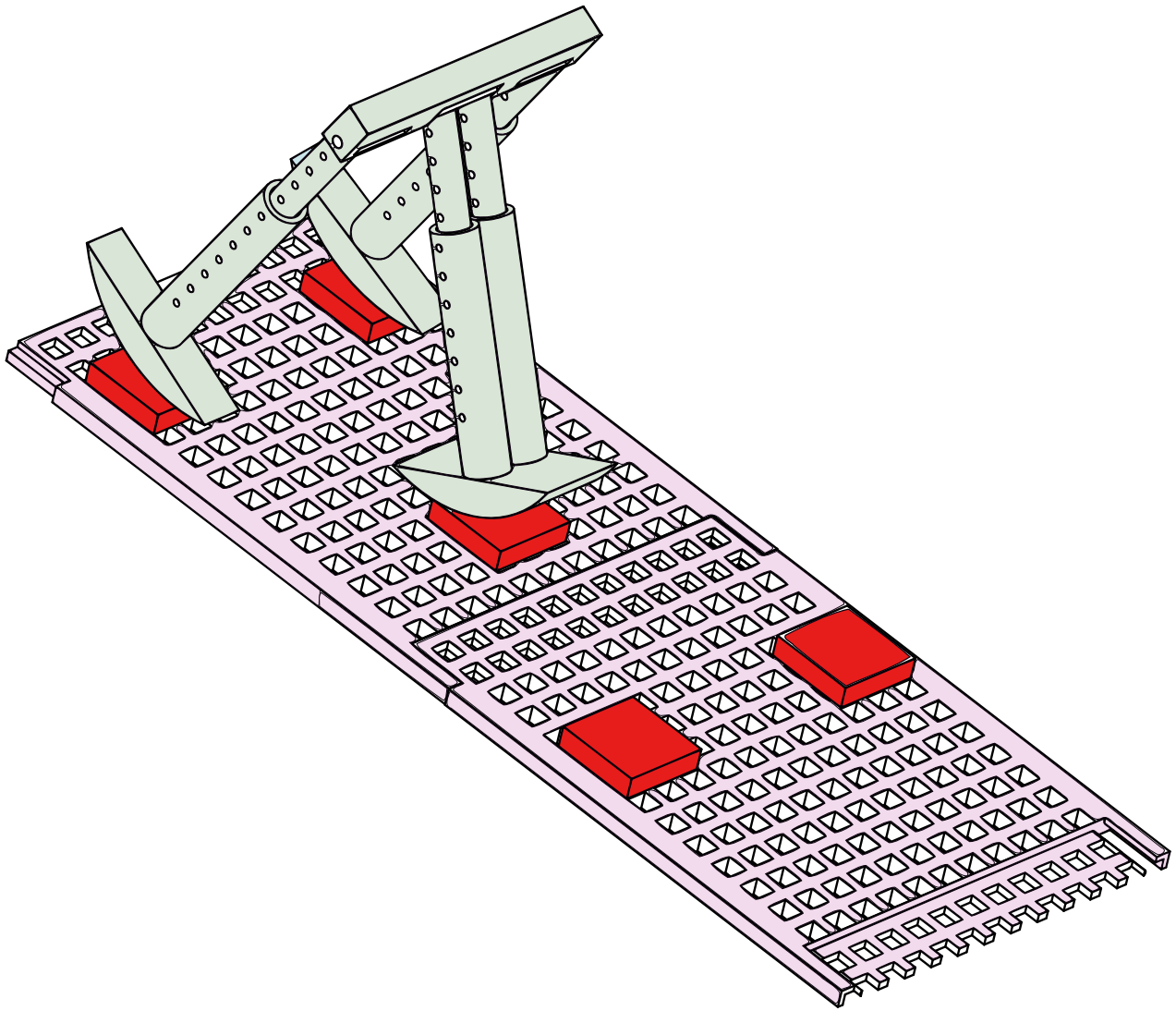
Weather is hard to predict

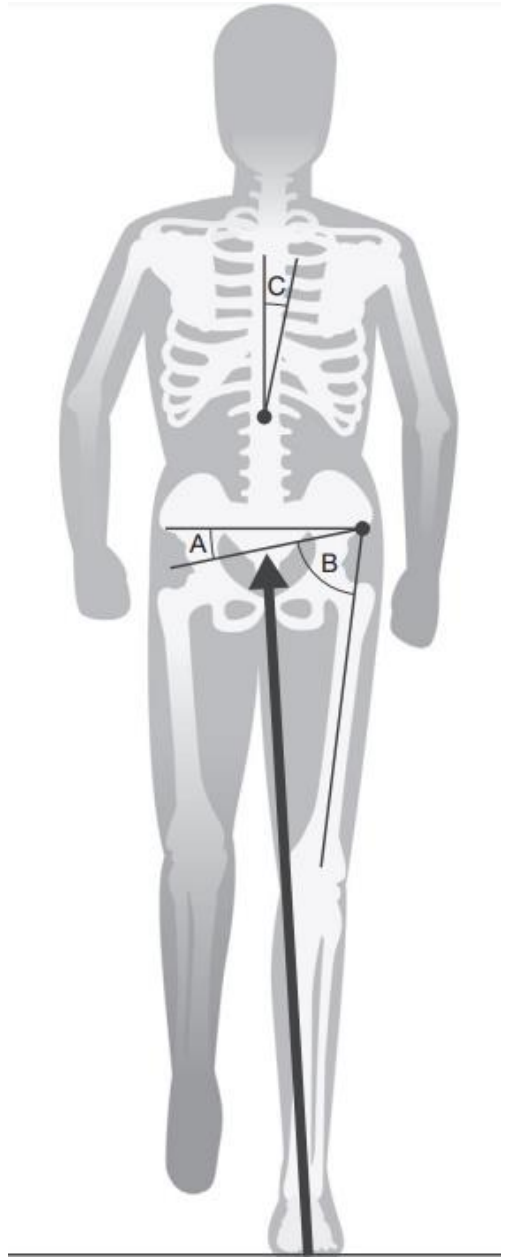
https://images.app.goo.gl/uzq3zEXSXYi5Rown9

Final Thoughts

Q: Why do you think the dog never tripped over, unlike the humans?
Hint: Think about a chair. How many legs does it have?

4 legs vs 2?





Impact of passive dynamic walking?

Wrap-up

Q: Which force helps to push the walker down the ramp? **Ans: Gravity!**

Q: Which force prevents the walker from sliding? **Ans: Friction!**

National Biomechanics Day 2024 @ CMU!

When: April 6th, 2024

Who: Age 14-18

Cost: FREE!!

Website:
https://bit.ly/3PpsliM

SEE WHAT WE
HAD LAST YEAR!

References

[1] S.-J. Park *et al.*, “Phototactic guidance of a tissue-engineered soft-robotic ray,” *Science*, vol. 353, no. 6295, pp. 158–162, Jul. 2016, doi: 10.1126/science.aaf4292.

Jellyfish: https://www.youtube.com/watch?v=9z8ujpPgUjI

Fish and seahorse: https://www.youtube.com/watch?v=prfZFyp4XZk

[2] https://www.youtube.com/watch?v=RtUQ_pz5wlo

[3]*Aplysia*: https://www.youtube.com/watch?v=EwumPoQf6uc

[4] https://www.youtube.com/watch?v=Uj0EVT-Ekog

[5] Zug, George R.. "locomotion". *Encyclopedia Britannica*, 13 Feb. 2020, https://www.britannica.com/topic/locomotion. Accessed 23 March 2022.

Exoskeleton: https://www.youtube.com/watch?v=tTBoYt8Pz_w

Atlas: https://www.youtube.com/watch?v=tF4DML7FIWk

Failures: https://www.youtube.com/watch?v=g0TaYhjpOfo

Leonardo Fly + Walk: https://www.youtube.com/watch?v=H1_OpWiyijU

McGeer Passive Dynamic Walker: https://www.youtube.com/watch?v=-YYVH36wDGE

Japanese Passive Dynamic Walker: https://www.youtube.com/watch?v=rhu2xNIpgDE&t=12s

Running: https://www.youtube.com/watch?v=YQD6_5XoBII

Gait cycle:

T. K. Uchida, S. L. Delp, and D. Delp, *Biomechanics of Movement: The Science of Sports, Robotics, and Rehabilitation*. Cambridge, UNITED STATES: MIT Press, 2021. Accessed: Apr. 01, 2022. [Online]. Available: http://ebookcentral.proquest.com/lib/cm/detail.action?docID=6434343

References

[1]
M. Tjur, A. R. Pedersen, W. Sloth, K. Søballe, N. D. Lorenzen, and M. Stilling, “Posterior or anterolateral approach in hip joint arthroplasty - Impact on frontal plane moment,” *Clinical Biomechanics*, vol. 54, pp. 143–150, May 2018, doi: 10.1016/j.clinbiomech.2018.03.017.

Bing AI generator

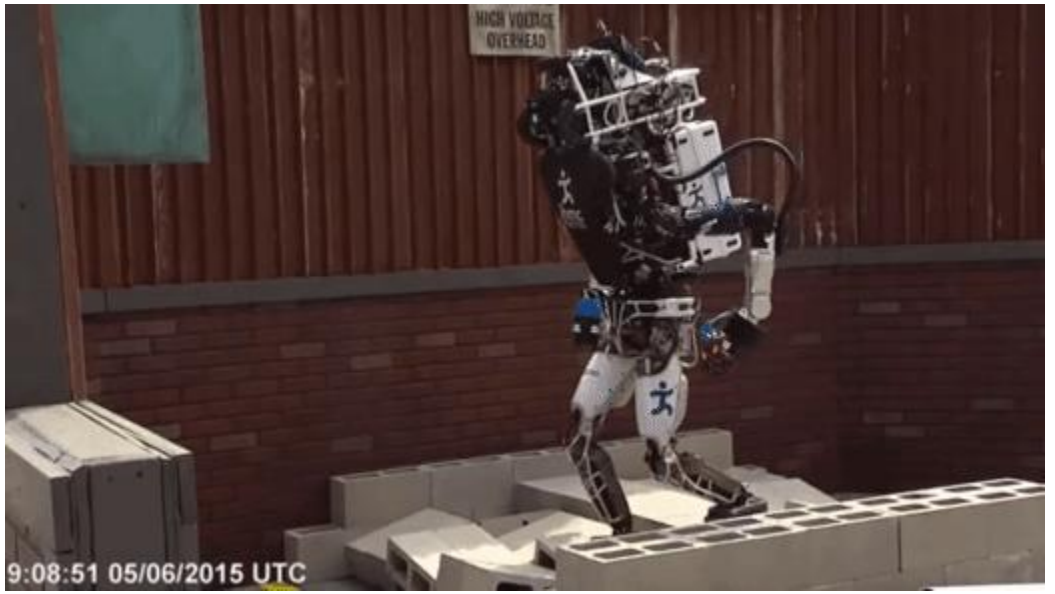
Ice slipping video: https://www.youtube.com/watch?v=aylO_1DSdts

Backup Slides

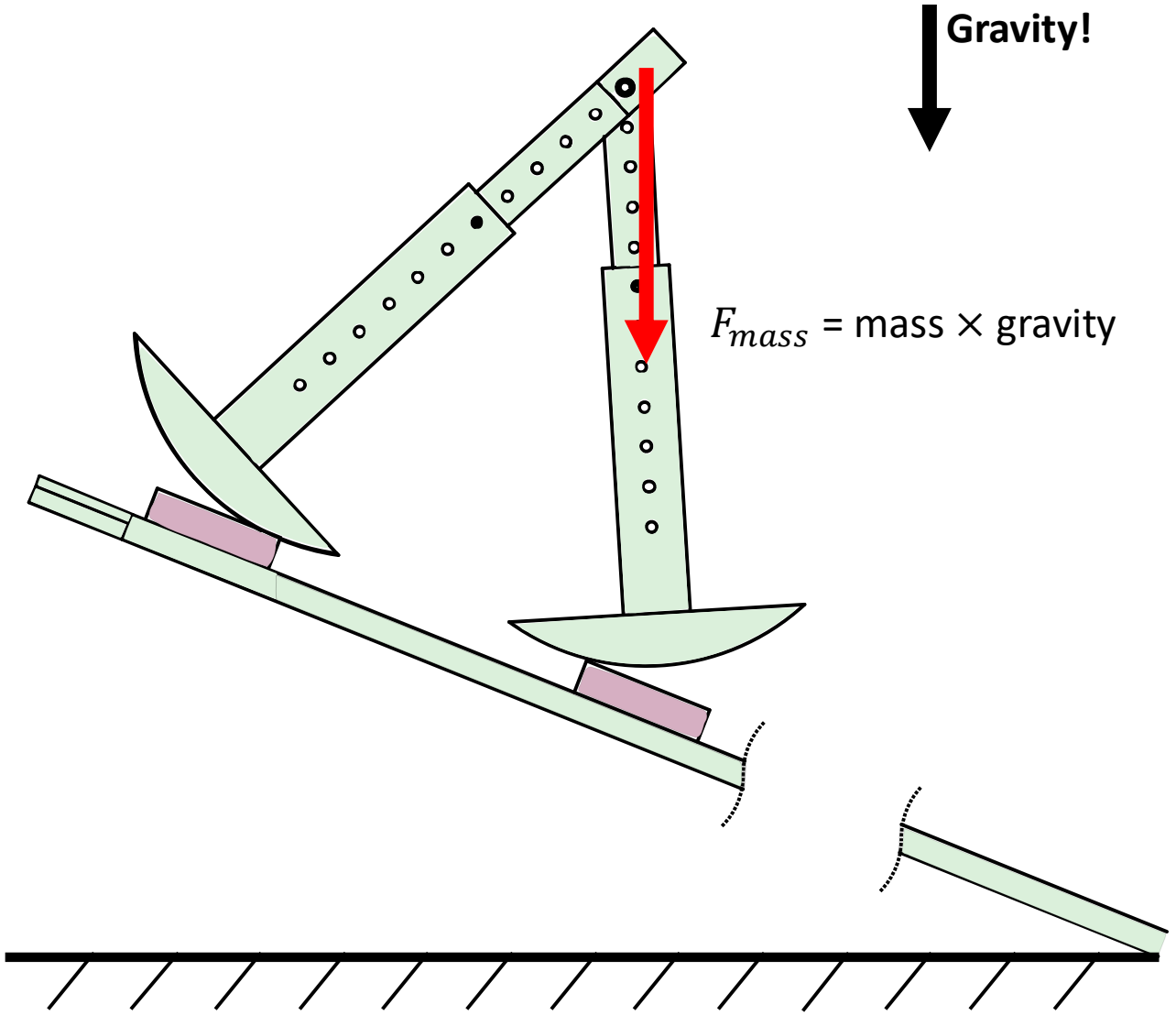
Robotic walkers

Robots have become better at locomotion …

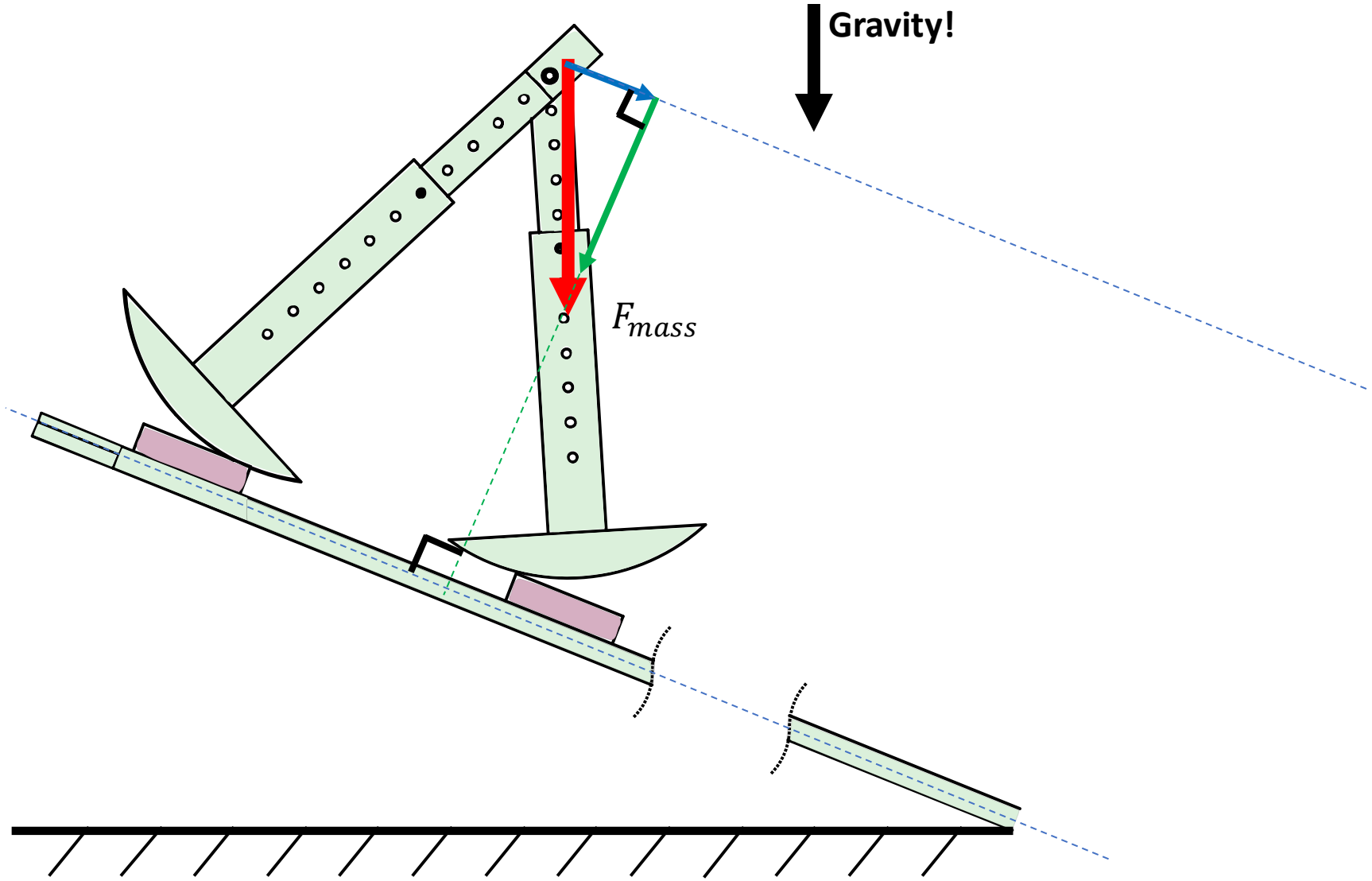
…but they are still not perfect



What forces are acting on the walker?



What forces are acting on the walker?



What forces are acting on the walker?