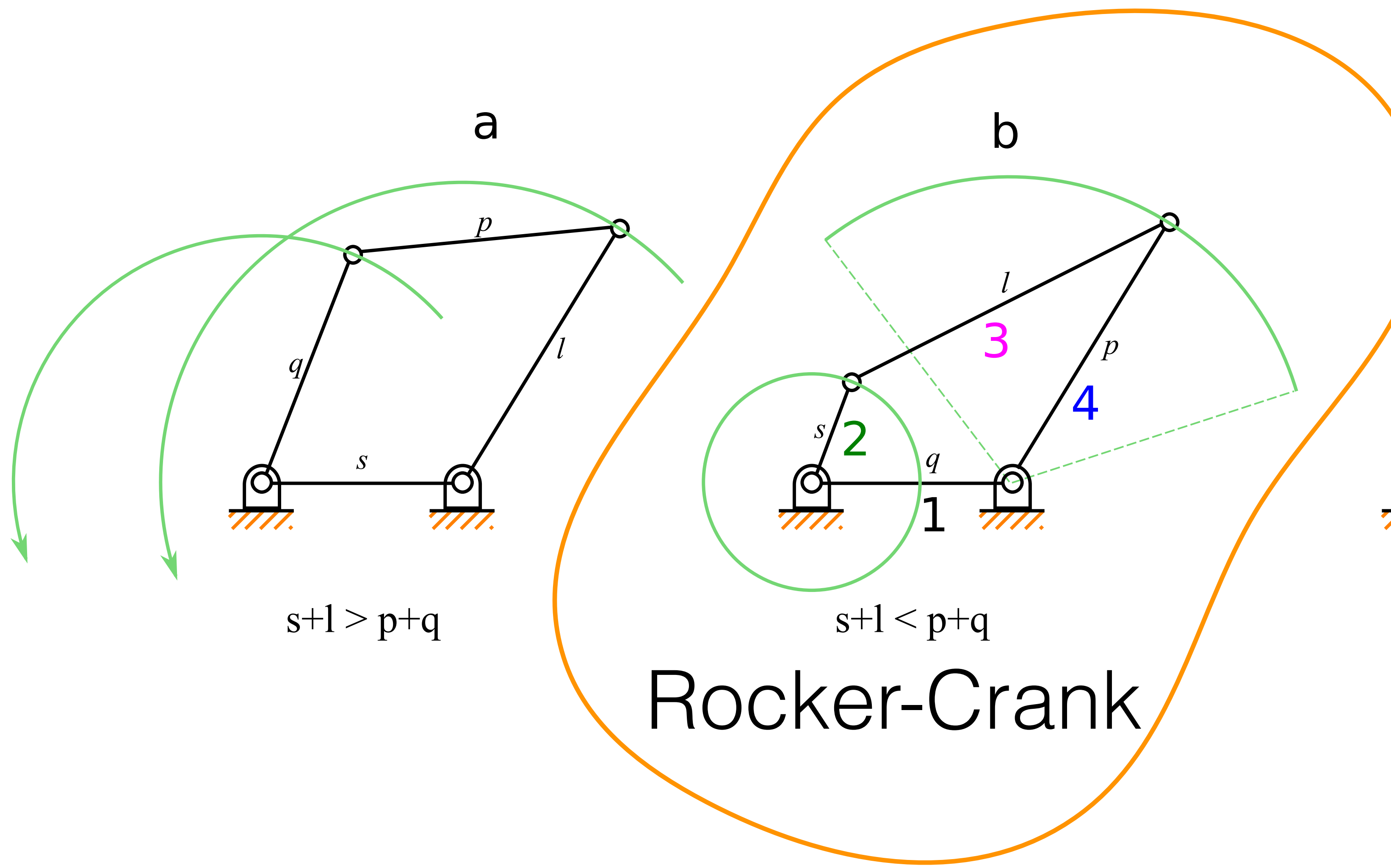
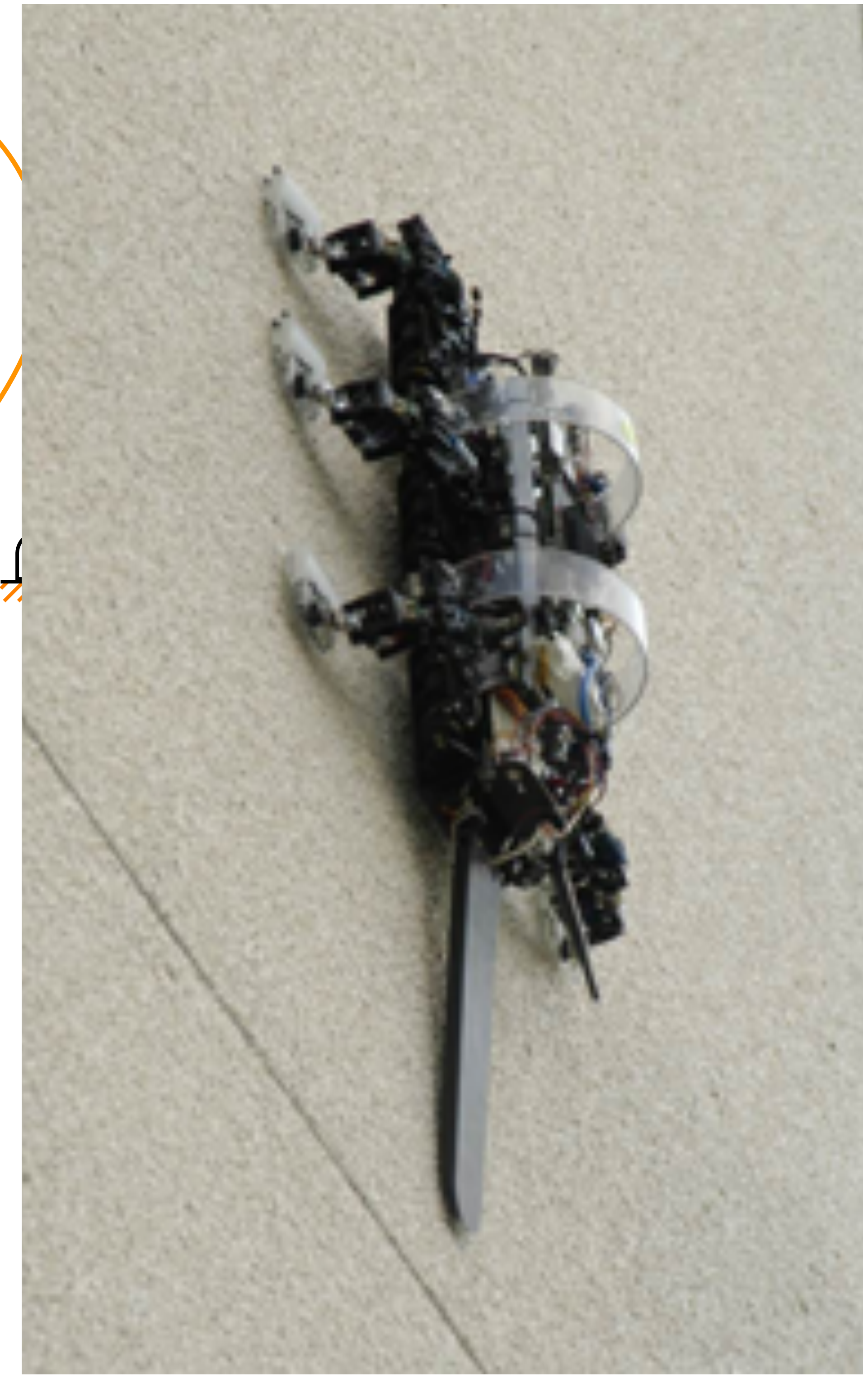
Grashof

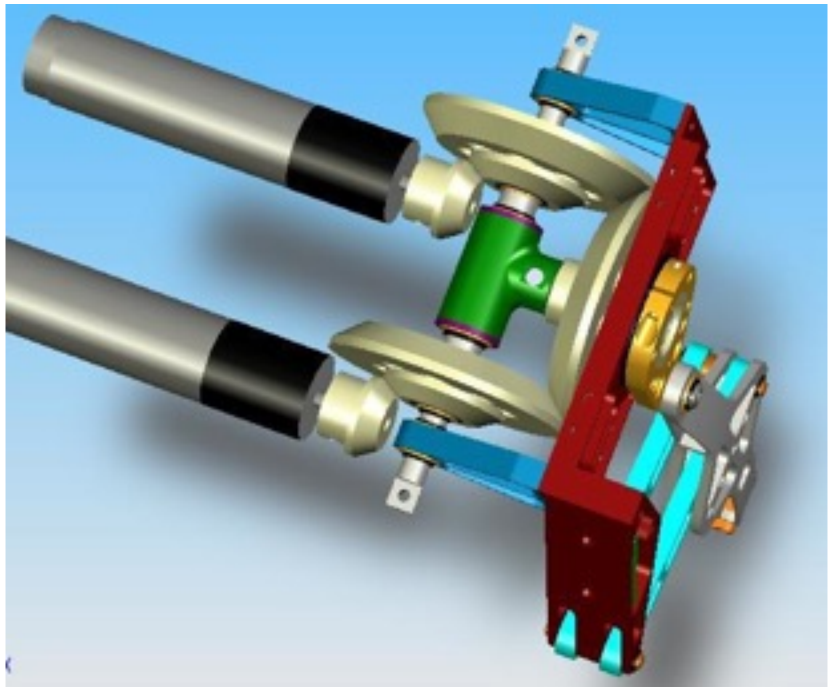
shortest + longest < sum of the others



Boston Dynamics RiSE

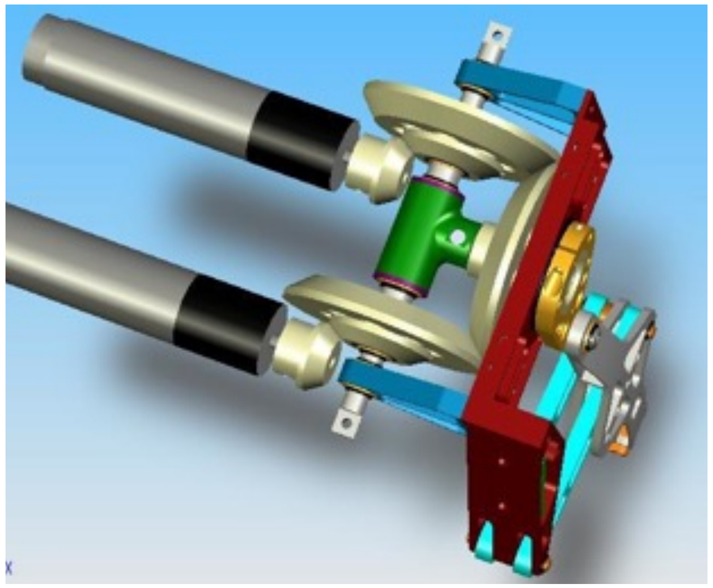


ME112: Four Bar Linkage

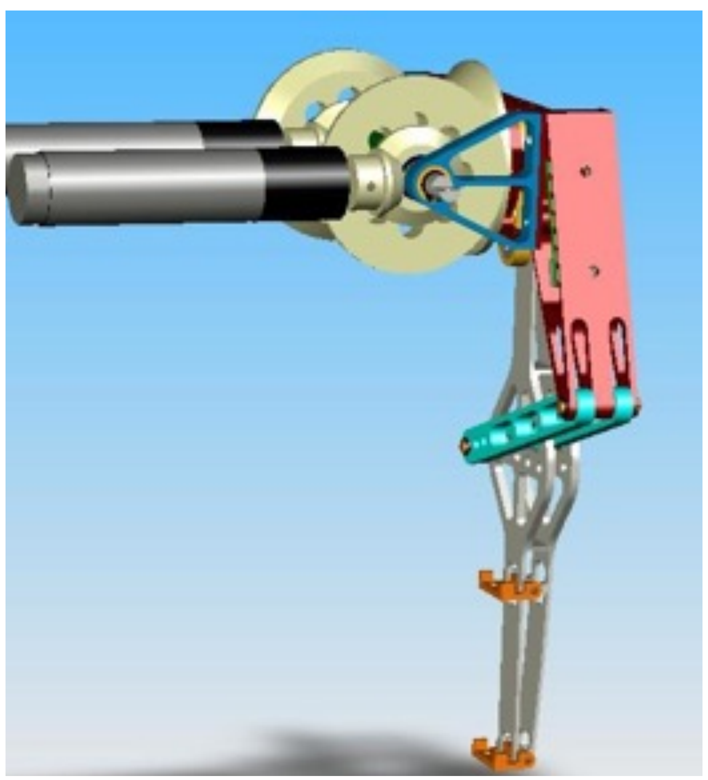


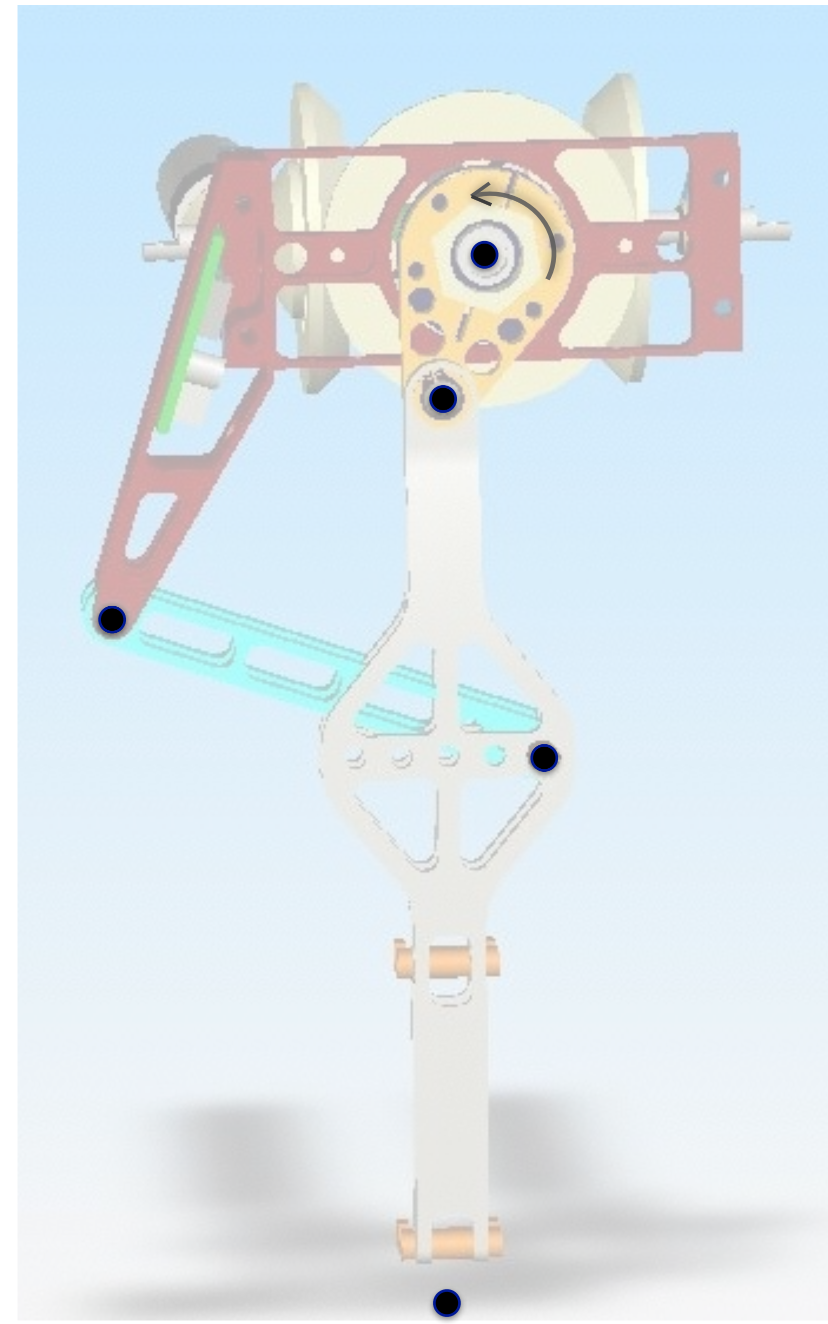
Top and
Front views
of the RISE
robot
leg linkage

ME112: Four Bar Linkage

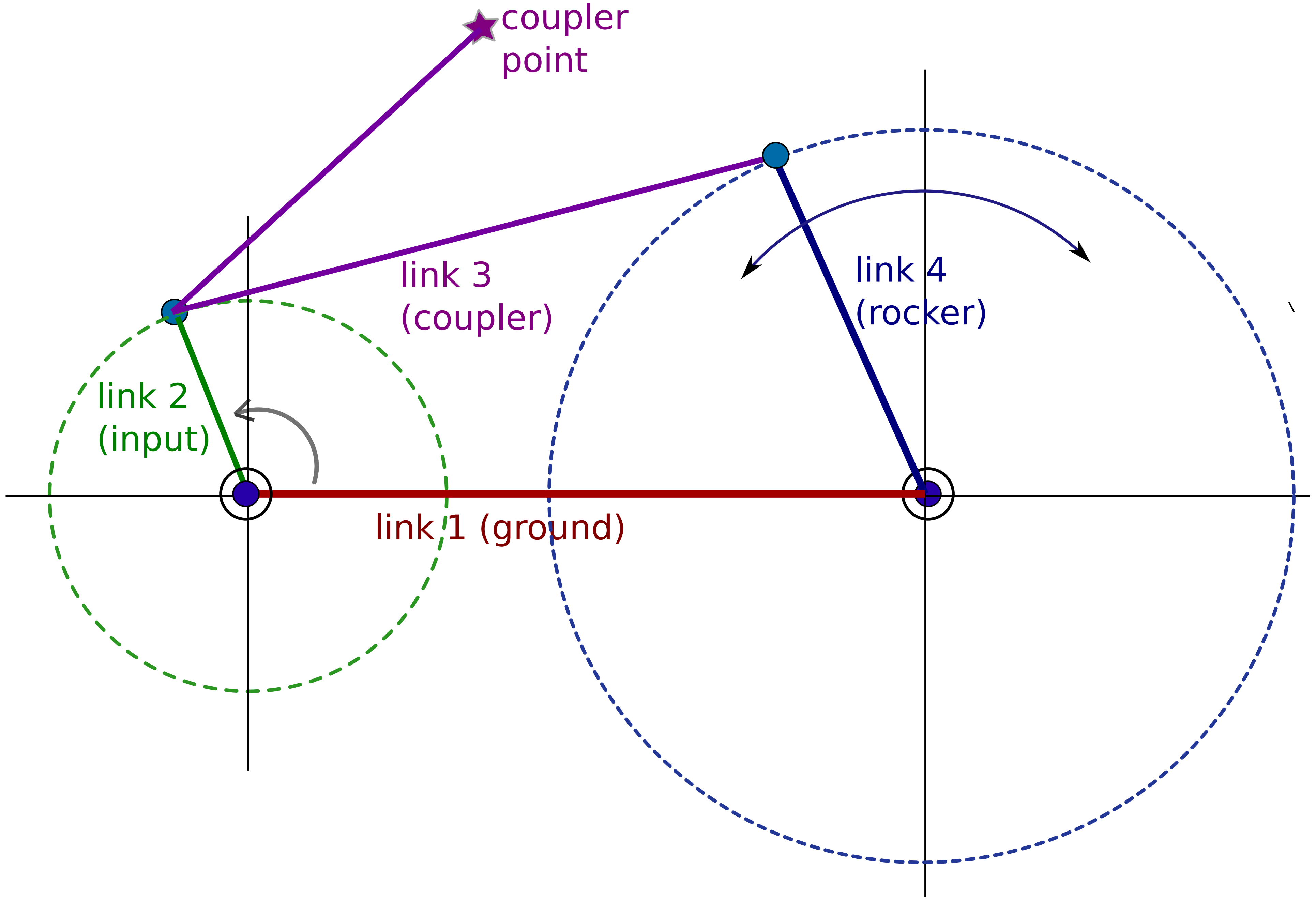


Top, Left side, and Front views of the RISE robot
leg linkage

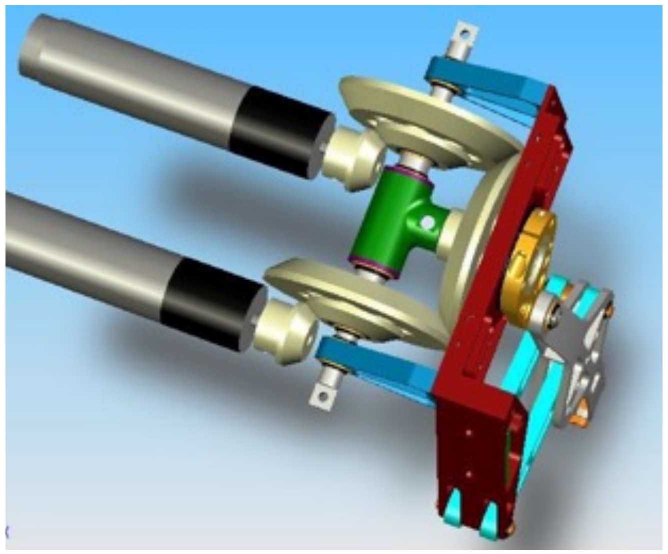




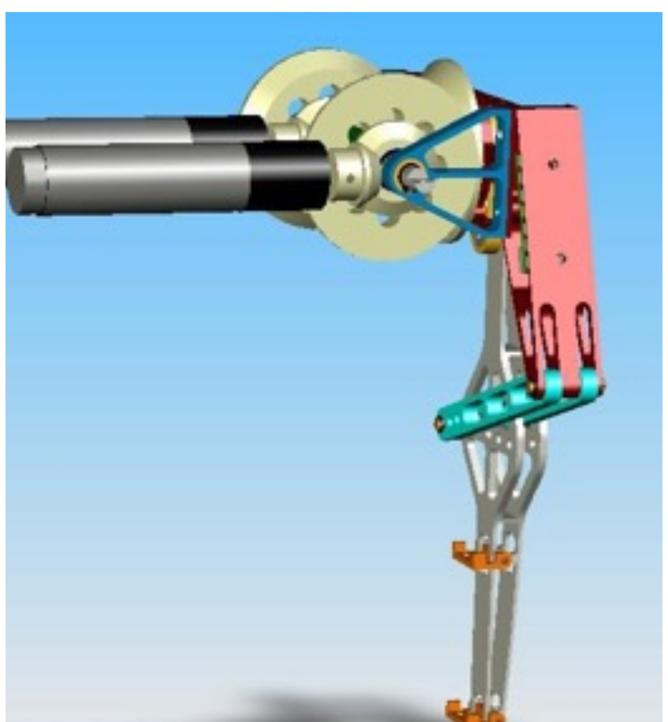
ME112: Four Bar Linkage

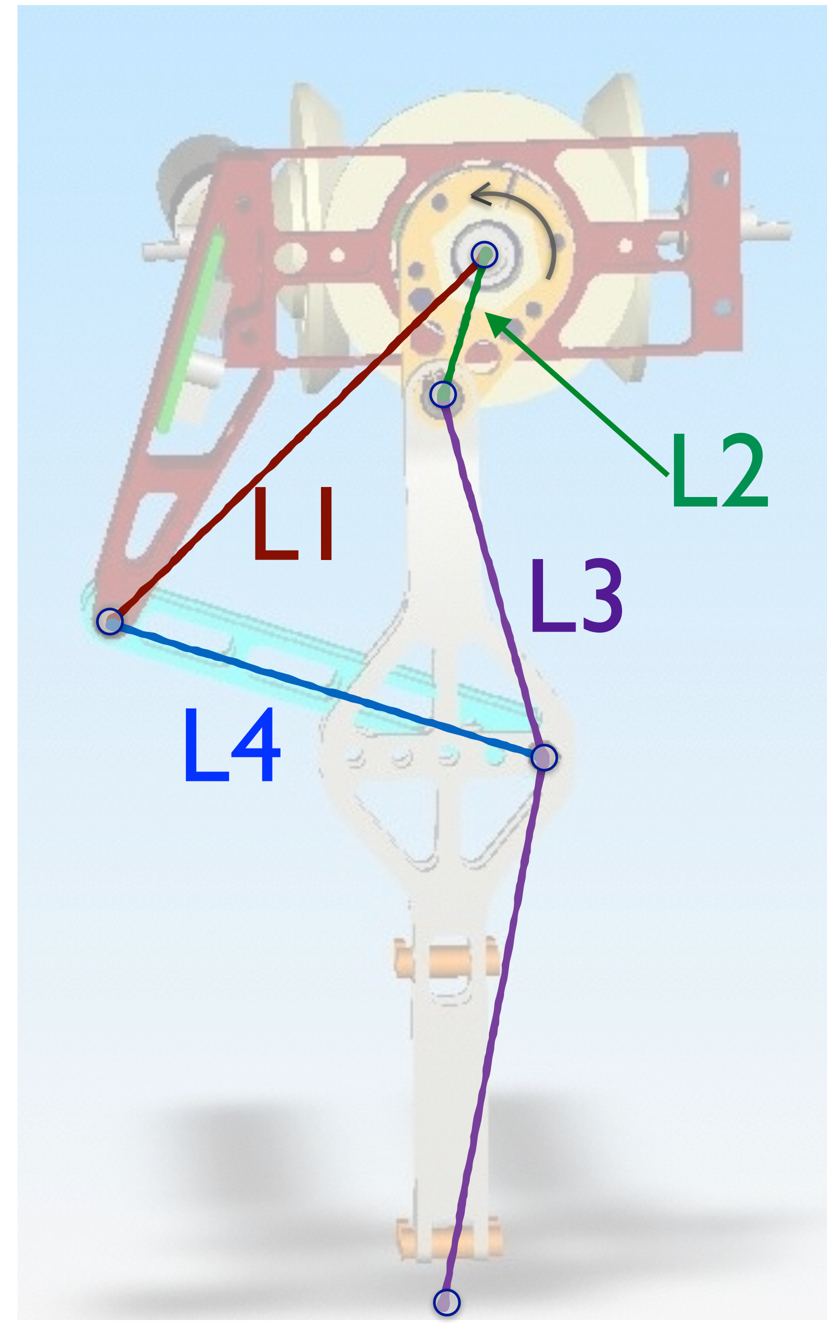


ME112: Four Bar Linkage

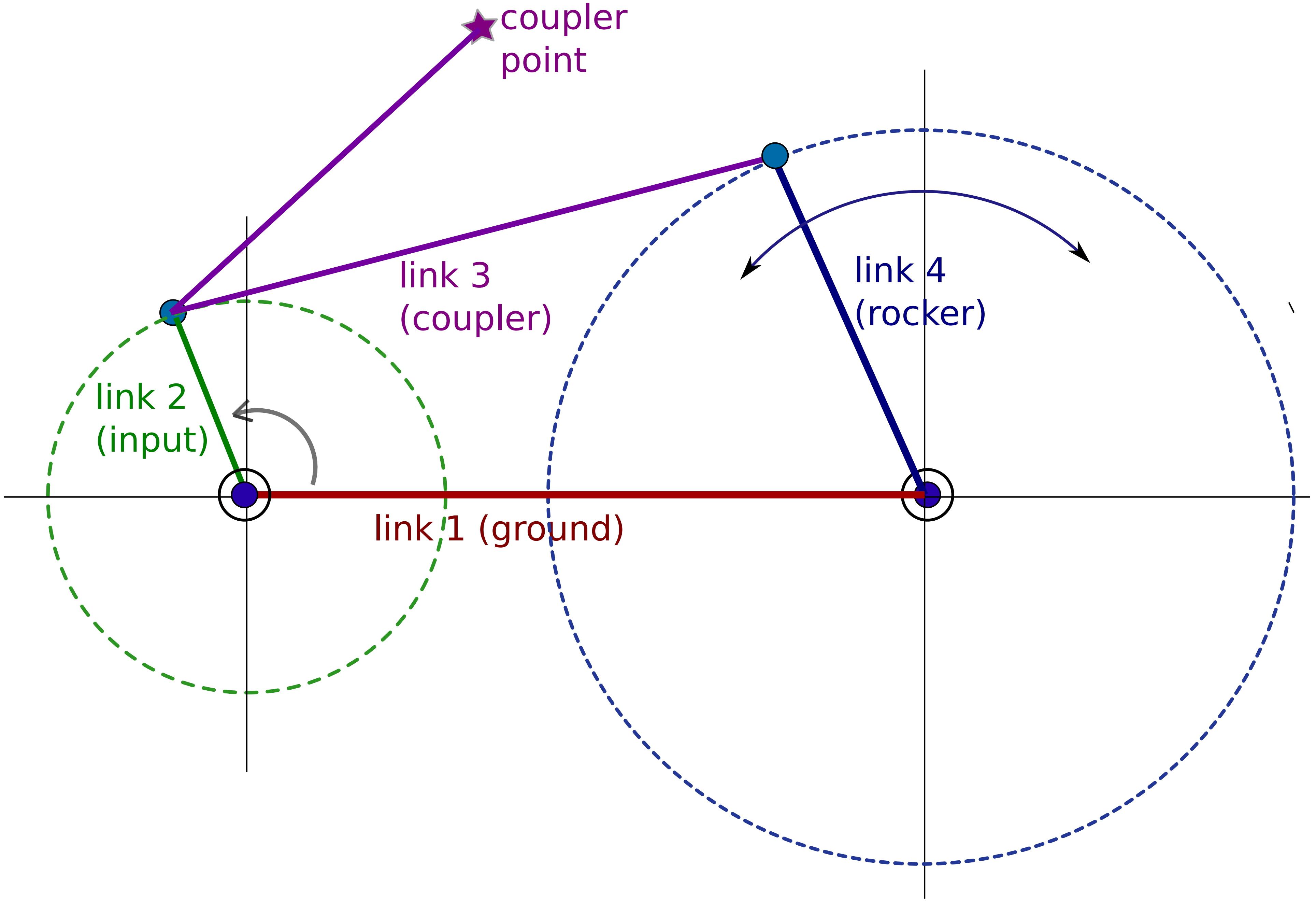


Top, Left side, and Front views of the RISE robot leg linkage

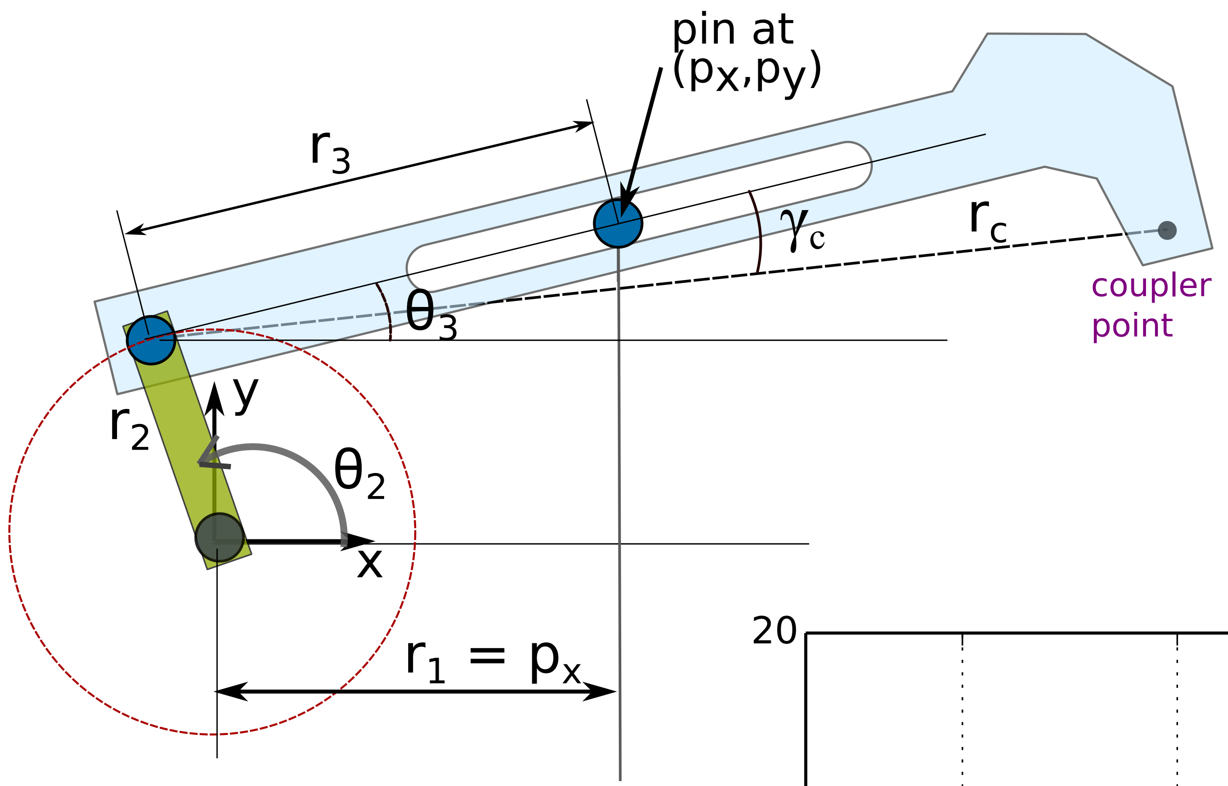


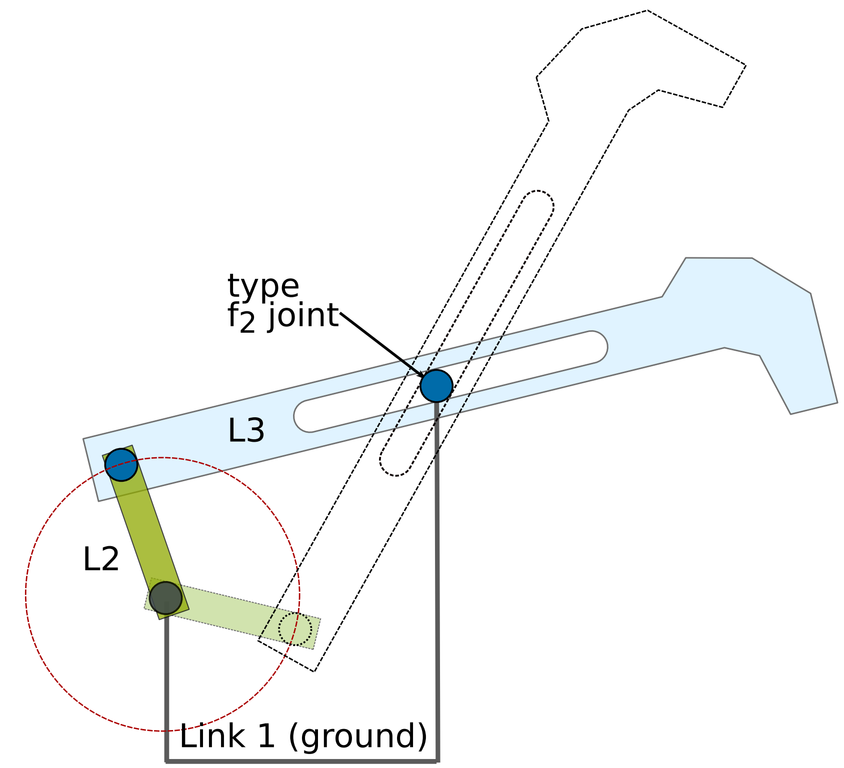


ME112: Four Bar Linkage

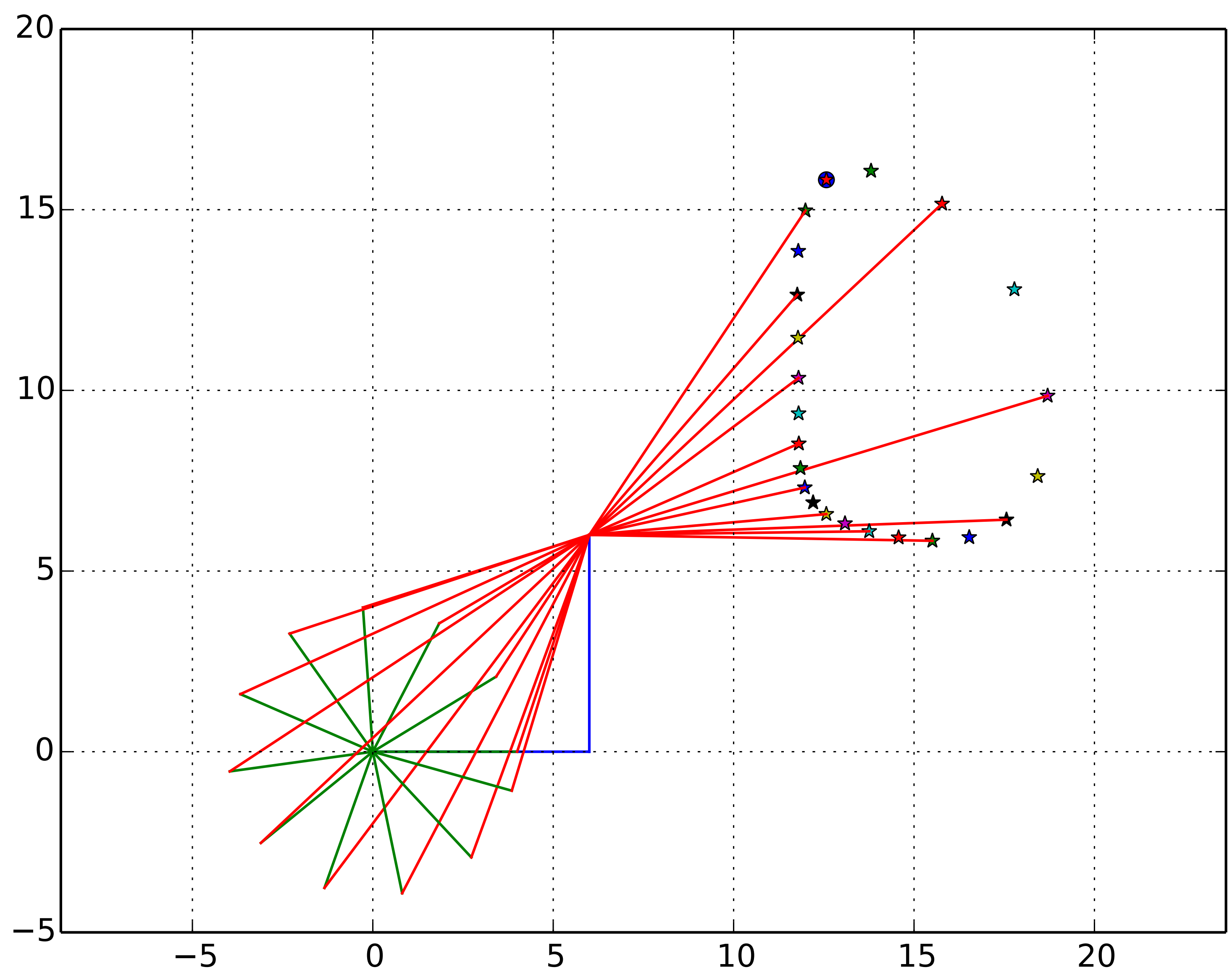


Pin-slider mechanisms





Python script posted on Canvas: LinkageUtilities

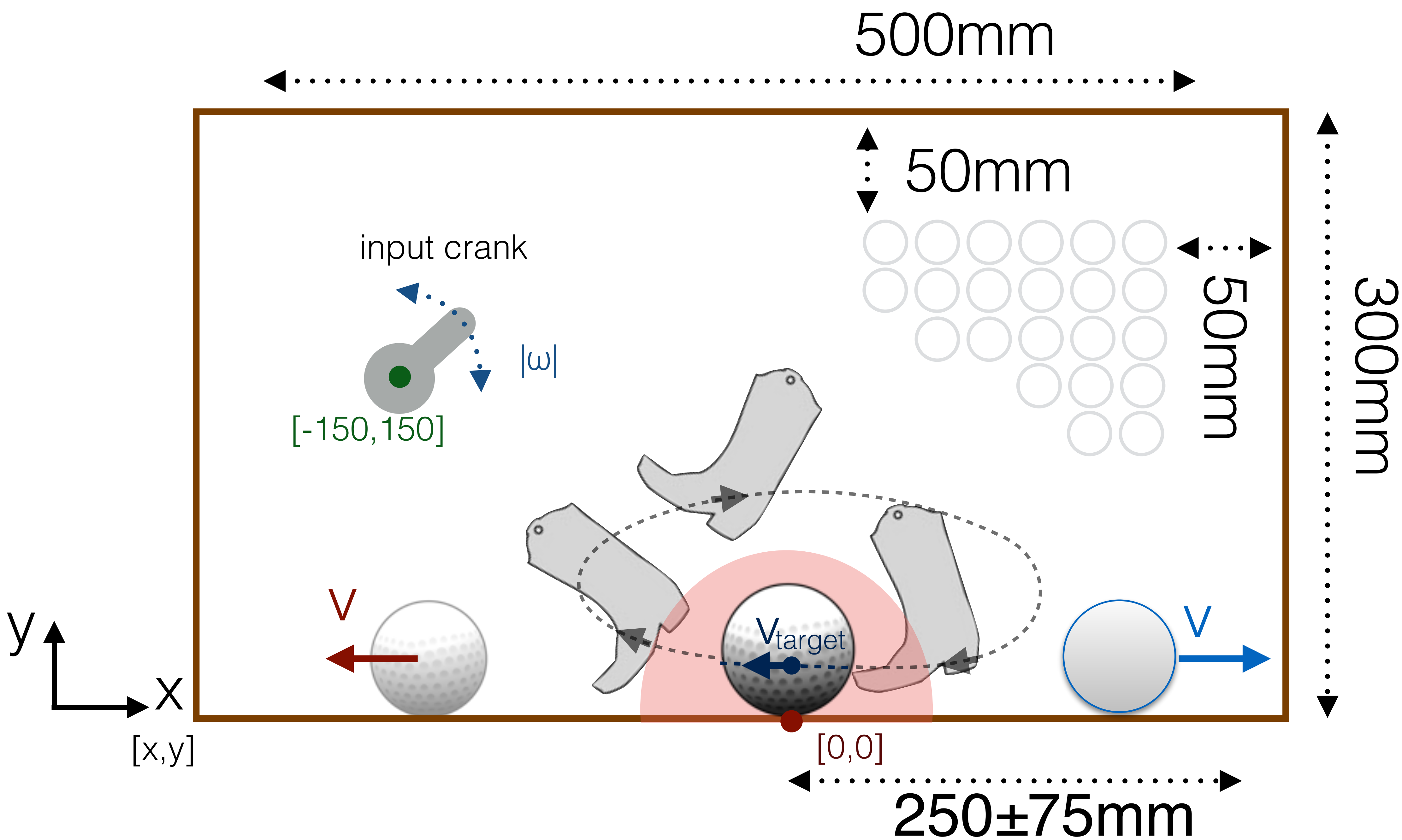


Summary:

- Depict linkage as a series of vectors: $\vec{r_1}, \vec{r_2}, \vec{r_3}, \vec{r_4}$.
- Add fictitious hypotenuse, and use Law of Cosines to solve for angles.
- Keep track of which quadrant (0, $\pi/2$, π, $3\pi/2$, 2π) angles are in.
- Using *tan half angle* identity, one can convert equations to a quadratic, for which the roots are the two inversions

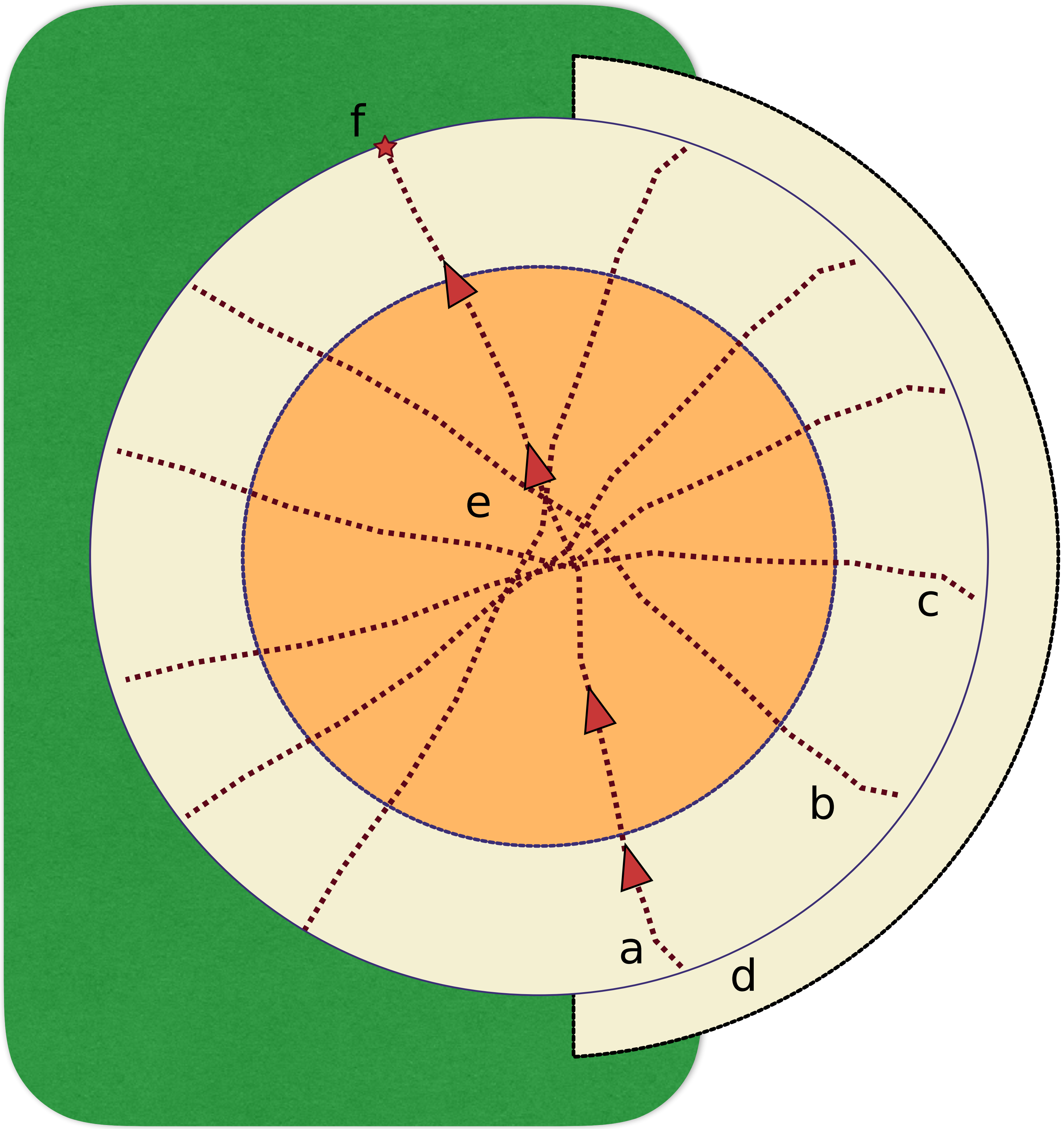
Video: https://www.youtube.com/watch?v=4fMRIrNLB58

Linkage warmup - done by final crawler teams



Pentapedal Locomotion

Pentapedal Locomotion



a. Roo released, heads across toward tasty grass.

b. 2nd roo released ~5 seconds later

c. 3rd roo, ~5 seconds later (etc.)

d. Bench

e. Possible congestion zone in area with paving blocks

f. Finish (pickup by hand)

Final project background

http://www.nytimes.com/2014/07/28/science/for-kangaroos-tail-becomes-a-fifth-leg.html

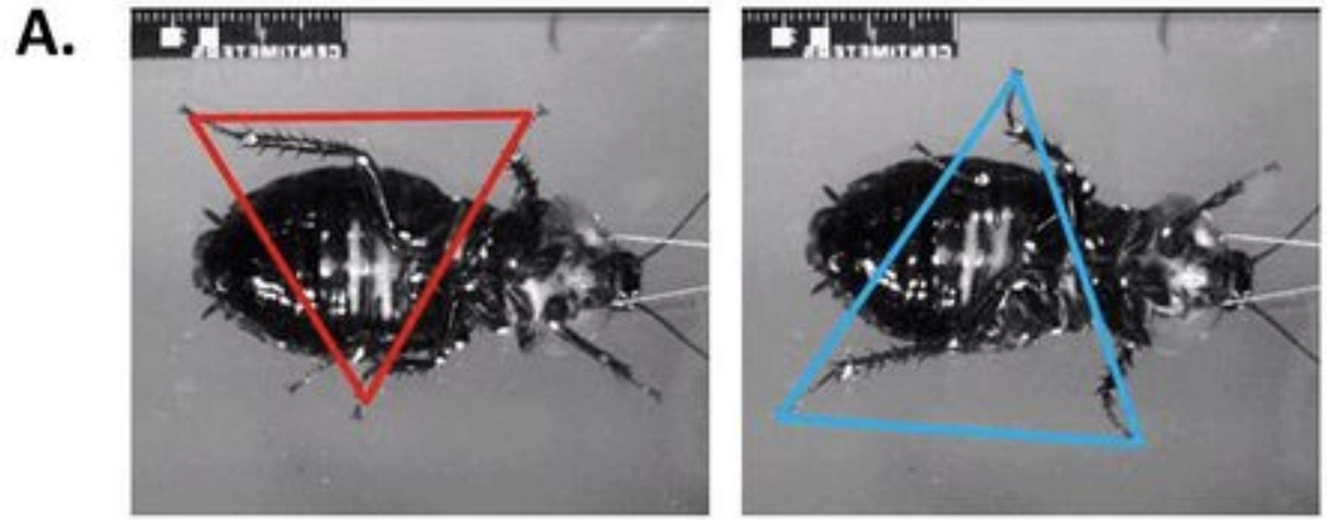
S. O'Connor *et al.*, "The kangaroo's tail propels and powers pentapedal locomotion,"
http://rsbl.royalsocietypublishing.org/content/10/7/20140381
especially look at the "supplemental material"

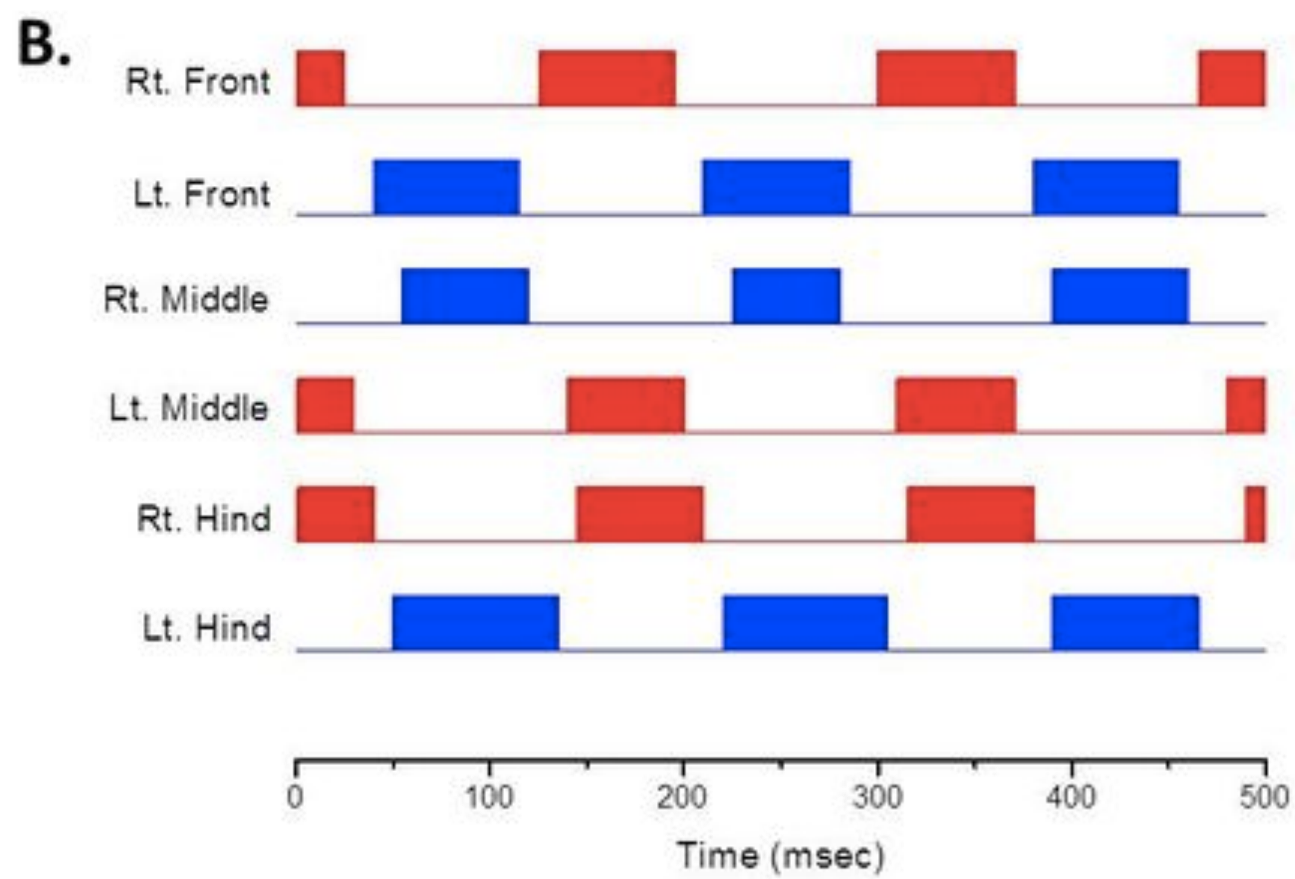
Animal Gaits

Insects use an alternating tripod under most circumstances.

Mammals use various quadrupedal gaits: diagonal stride, tripedal crawl, bound, gallop, etc. — tradeoff speed versus stability.

For programmable robots, gait tuning is an important topic; you will have a fixed gait, determined by your mechanism.

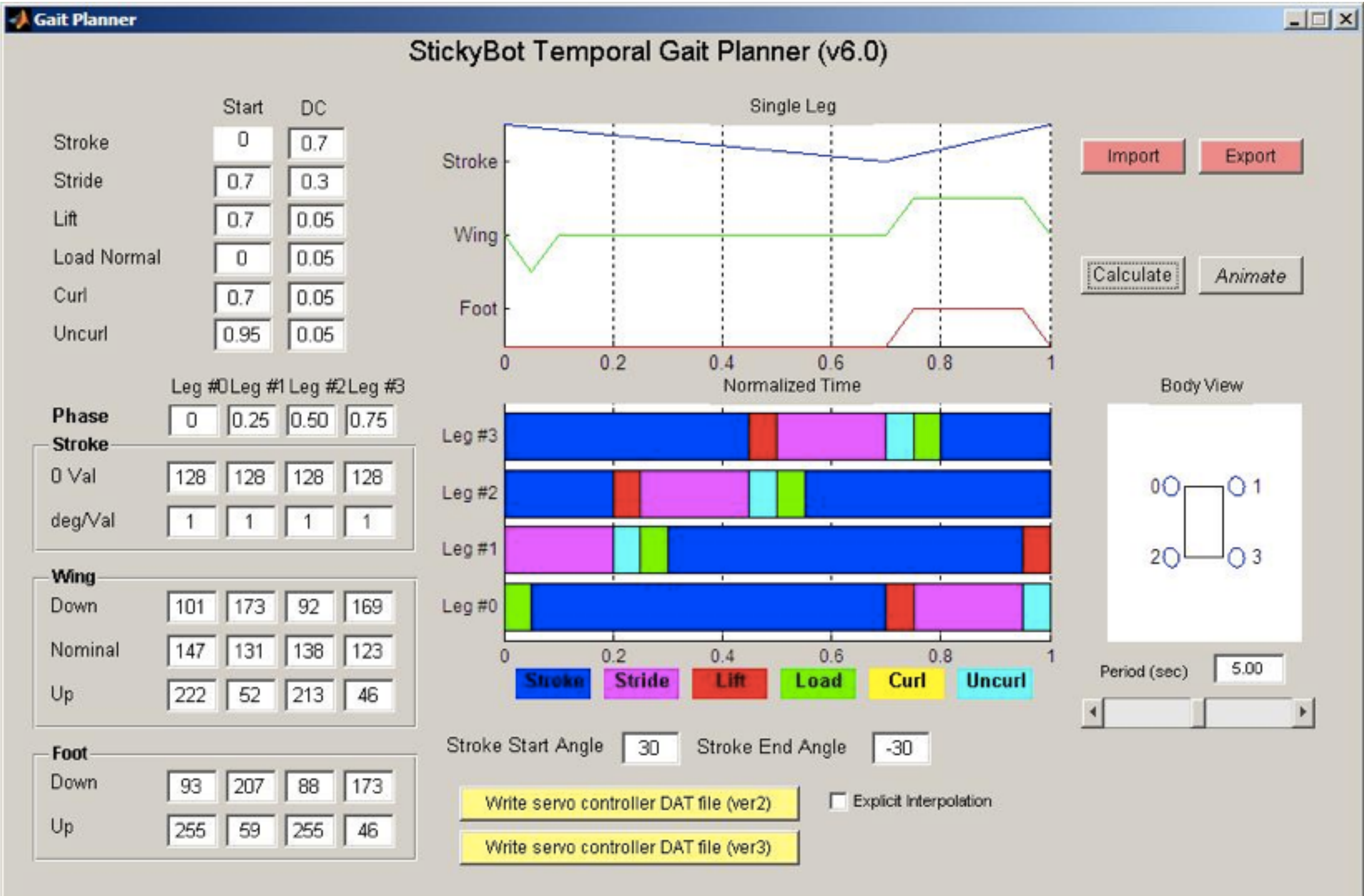




From Ritzman & Zill, "Neuroethology of Insect walking"

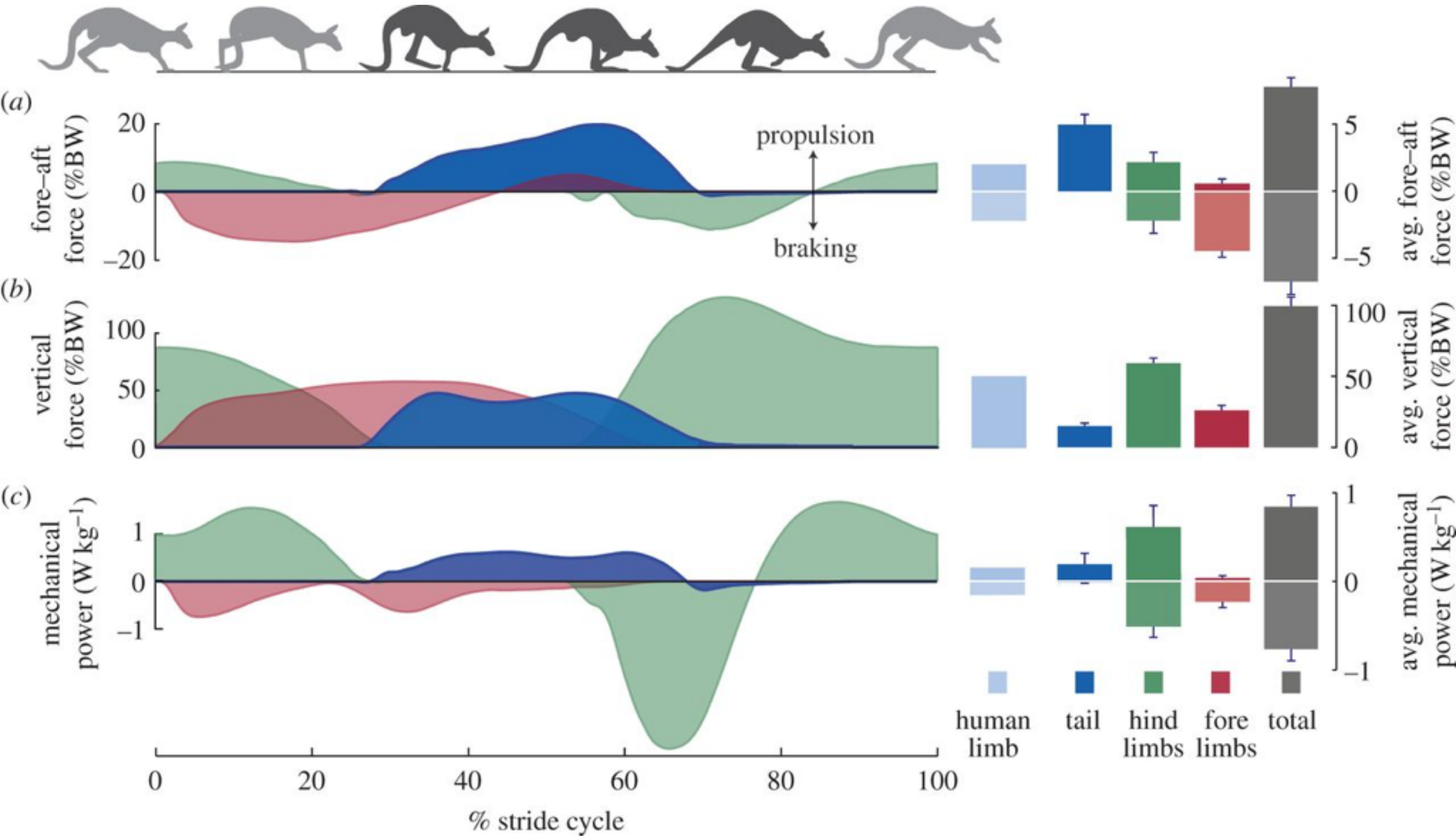
Gait tuning for RiSE, Stickybot

http://bdml.stanford.edu/twiki/bin/view/Rise/GaitPlanner.html

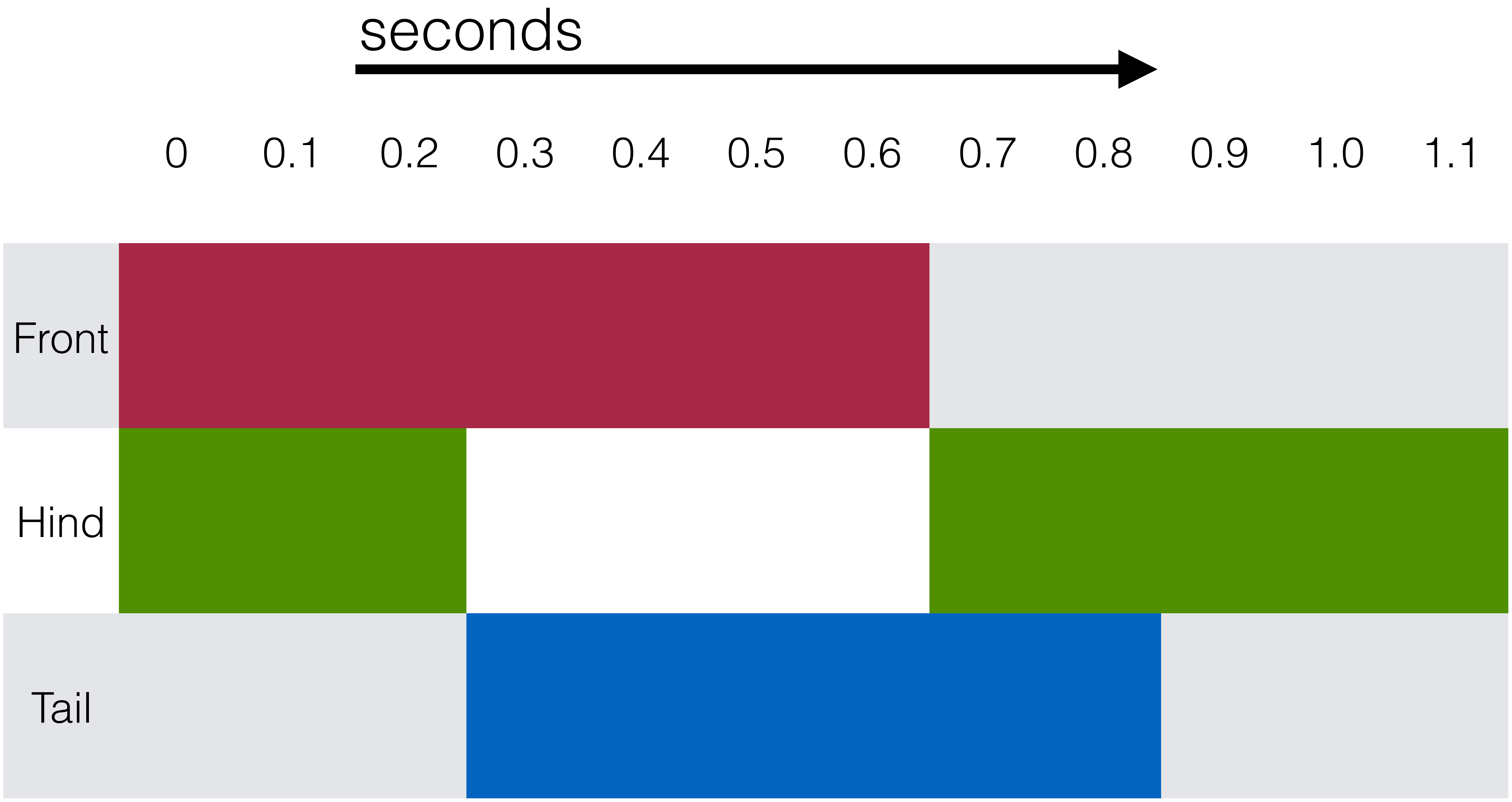


adjust relative phasing and overlap of left, right sides

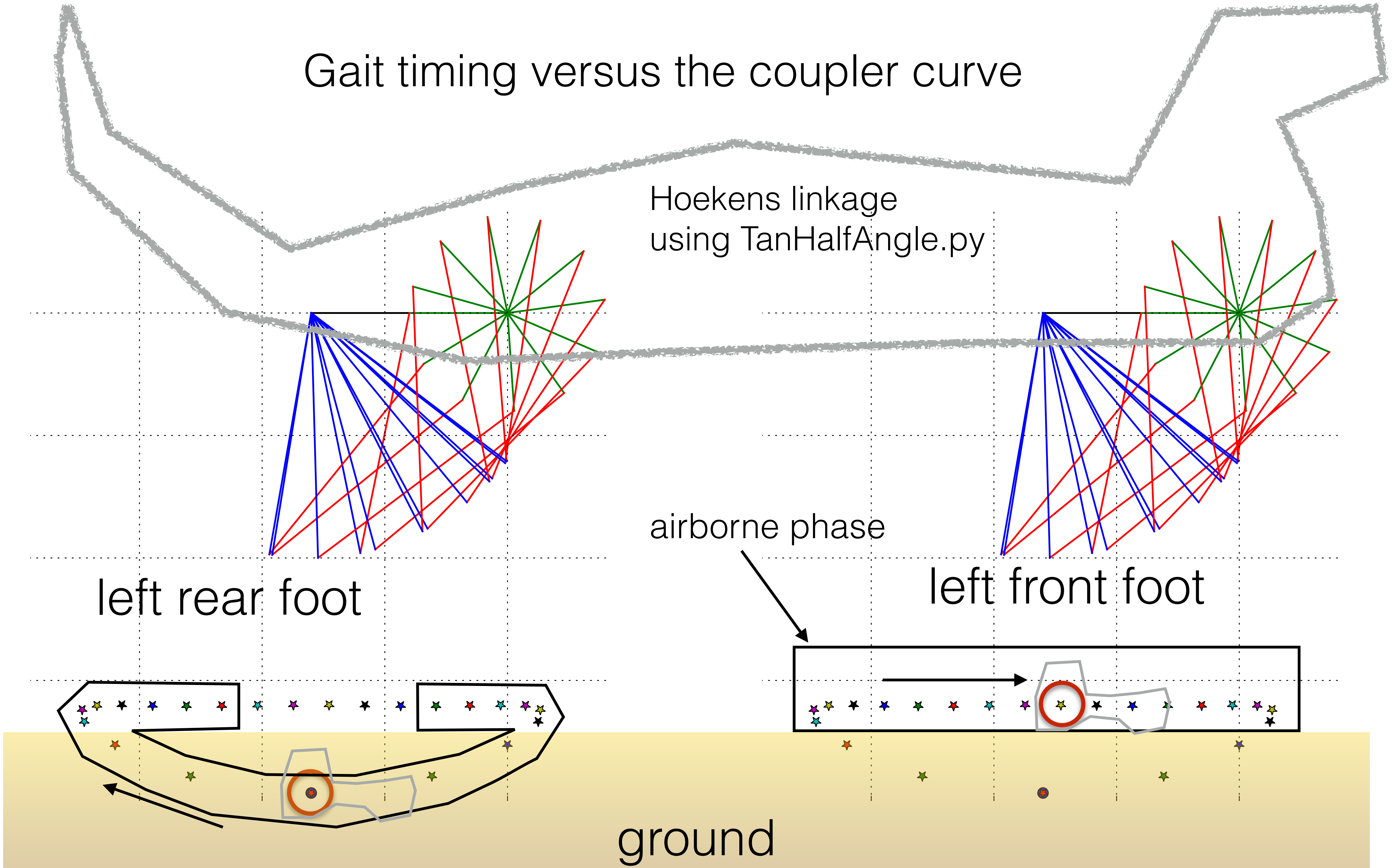
Force and **power** from each leg over the one stride (supplemental data from the article)



Approximate pentapedal gait chart



Gait timing versus the coupler curve



Good coupler curve shape, but wrong velocities — need more time on ground (slower) and less time in air (faster)

How to get started?

- Look at details of kangaroo pentapedal locomotion.
- Look at other small legged robots and toys for mechanism ideas.
- Look at various linkages and think about how they might be adapted.
- Use the **Atlas** and **Simulator** programs to get some ideas of plausible solutions (see LinkageLinks on Canvas)
- Experiment with Legos and then with Matlab, Python , etc.