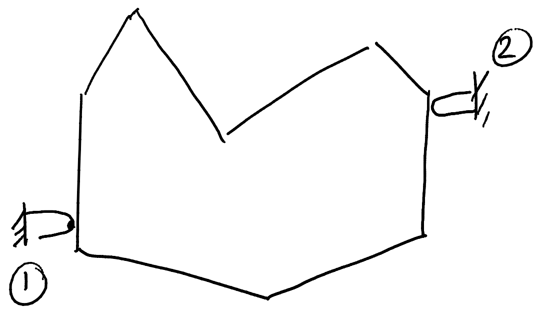
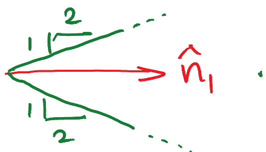
1. A planar object is grasped with two hard fingers. The coefficient of friction at both contact points is 0.5.

a. Show graphically that the grasp to the right has frictional form closure

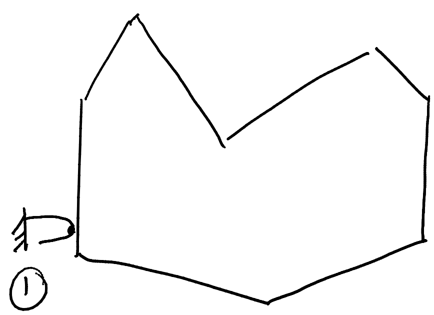


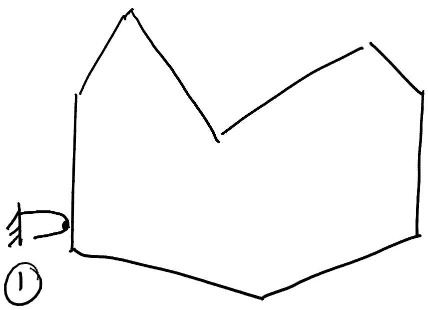
(Hint: estimate the friction cone geometry

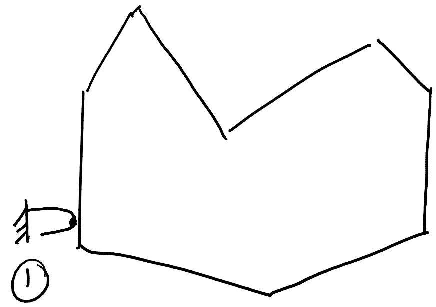


Your answer will be approximate. That is fine.)

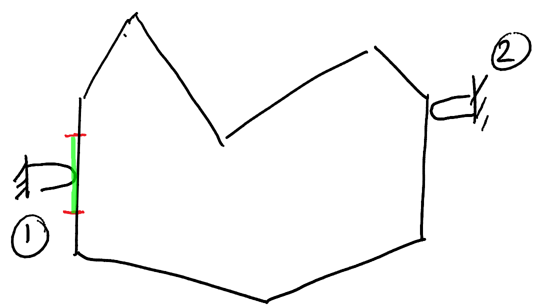
b. Assume contact ① is fixed. Highlight the edges of the object where the second contact could be placed such the grasp has frictional form closure.





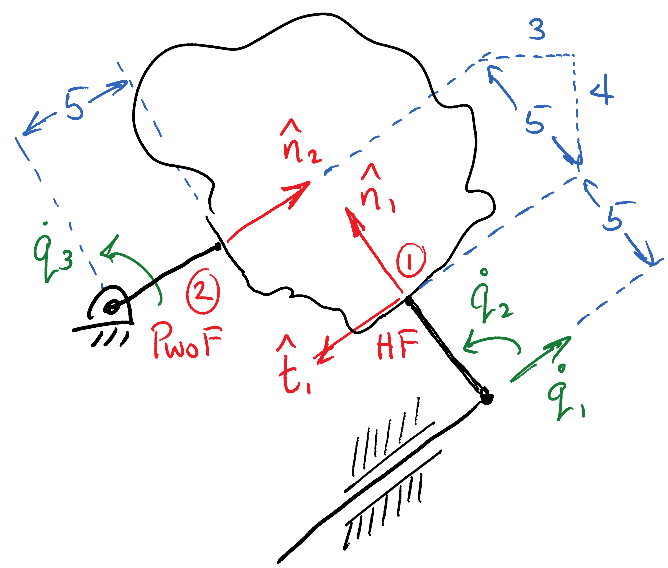


c. Suppose the robot is not perfectly accurate, so when attempting to place finger ① as shown, one can only guarantee that it is placed in the contact region shown. Assume also that finger ② <u>is</u> perfectly accurate. Sketch the region of finger ② placements that would yield frictional form closure



for every placement of finger ① inside the region shown. (Consider only the two edges that currently have contacts.)

.2 The hand in the planar system to the right makes two contacts with the object. Contact ① is modeled as a hard finger (point w/ friction) contact. The other as a point w/o friction.



a. Determine G & J

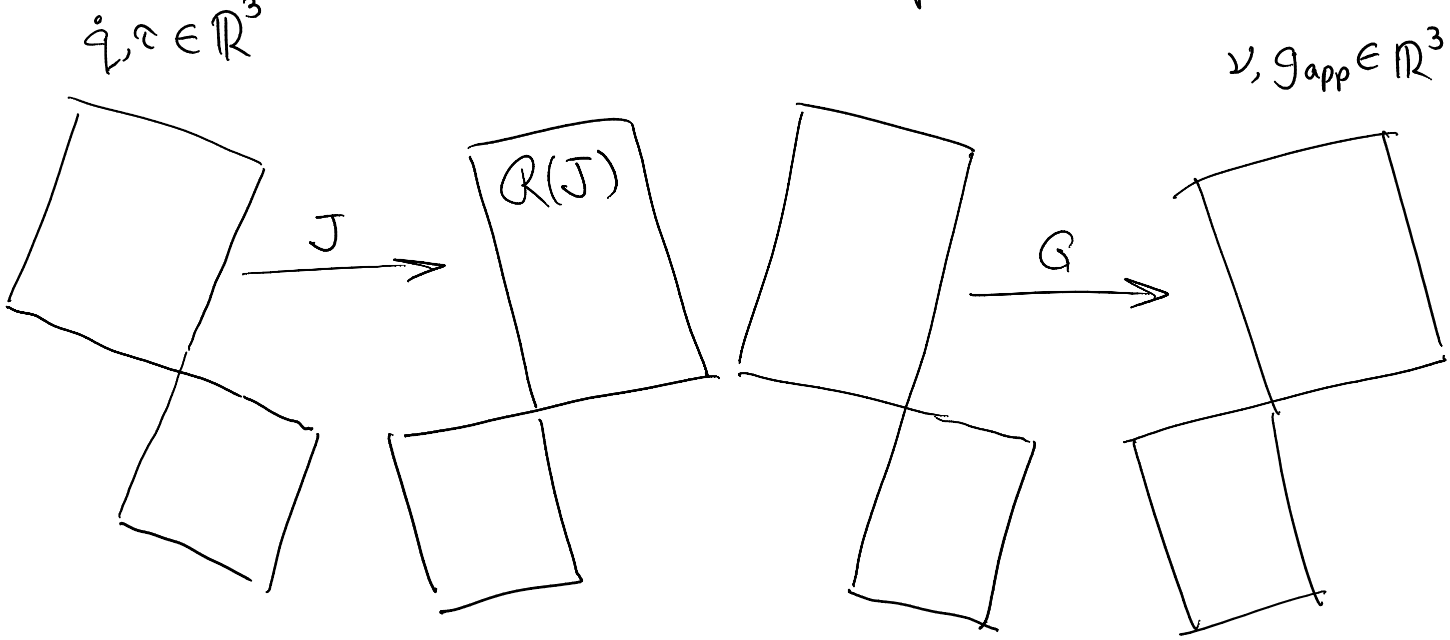
Before continuing, check G & J with Prof. Trinkle.

b. If the contact points on the fingers could move arbitrarily, could they be chosen to cause any desired $\nu \in \mathbb{R}^3$?

c. Does this grasp have form closure ?

d. Does the grasp have force closure?

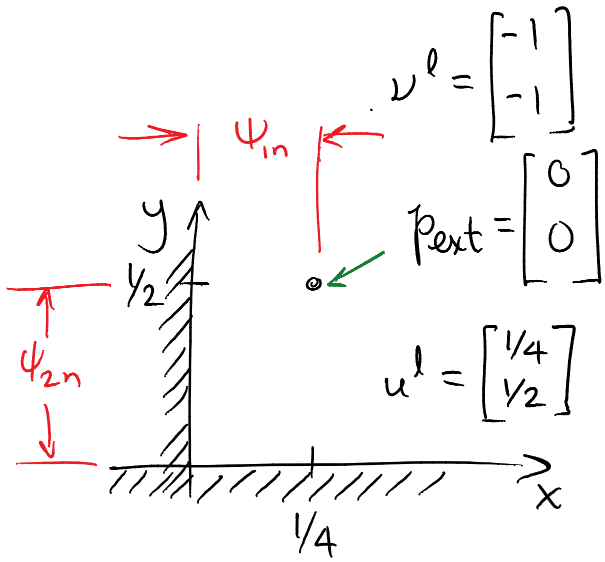
e. Complete the picture below, i.e. identify the dimensions of the various subspaces.



f. Identify an element of R(J) and interpret it in physical terms specifically applied to the hand. You can explain in terms of velocities or forces, whichever you are more comfortable with.

3. A frictionless particle moves toward a corner.

Let $m = h = 1$.



a. Set up the time-stepping LCP including both Ψ_{1n} & Ψ_{2n}.

b. Temporarily ignore Ψ_{2n}. Determine $u^{\ell+1}$ and $p_n^{\ell+1}$

Before continuing check with Prof. Trinkle

c. For the next time step include both constraints. Compute p_n^{l+2} and u^{l+2}.

d. Assume that Coulom friction with coefficients μ_1 & μ_2 act between the particle and the two constraint surfaces. Define E, U, G_f for this problem.