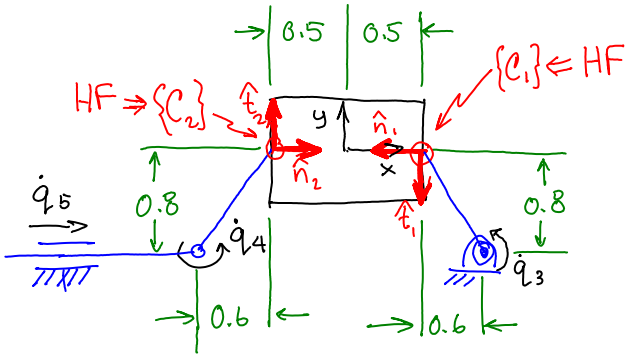
2009 mdtrm

Saturday, February 28, 2009
12:57 PM

0. 2D Problem!

21 pts



a. Construct G & J assuming HF contacts.

b.) With the correct G & J, Matlab gives:

$\text{Rank}(G) = 3$ $\qquad$ $\text{Rank}(GJ) = 3$

$$\text{null}(G) = \begin{bmatrix} 1 \\ 0 \\ 1 \\ 0 \end{bmatrix} \qquad \text{null}(J^T) = \begin{bmatrix} 0.6 \\ -0.8 \\ 0 \\ 0 \end{bmatrix}$$

b.i.) Do the contacts provide enough constraint to move the object with a full 3 degrees of freedom? Why or why not?

b.ii.) Can the fingers control all 3 degrees of freedom

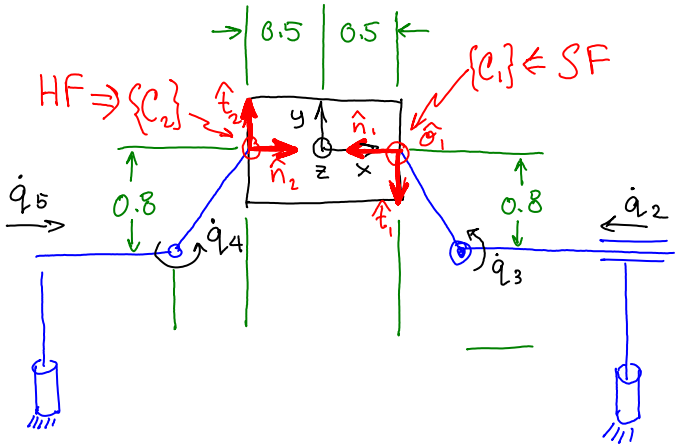
of the object? Why or why not?

b.iii.) Can the fingers control all internal forces? Why or why not?

b.iv.) null(G) & null(J^T) represent unachievable contact twists on the hand and object respectively. Give a physical interpretation of these unachievable twists.

1. 3D Problem!

25 pts



b.) With the correct G & J, Matlab gives:

Rank(G) = 6 Rank(GJ) = 5

$$\text{null}(G) = \begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \\ 1 \\ 0 \\ 0 \end{bmatrix} \begin{matrix} \} \text{SH} \\ \\ \\ \\ \} \text{HF} \\ \\ \end{matrix} \qquad \text{null}(J^T) = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \\ 0 \\ 0 \\ 0 \end{bmatrix} \begin{matrix} \} \text{SF} \\ \\ \\ \\ \} \text{HF} \\ \\ \end{matrix}$$

b.i.) Do the contacts provide enough constraint to move the object with a full 6 degrees of freedom? Why or why not?

b.ii.) Can the fingers control all 6 degrees of freedom of the object? Why or why not?

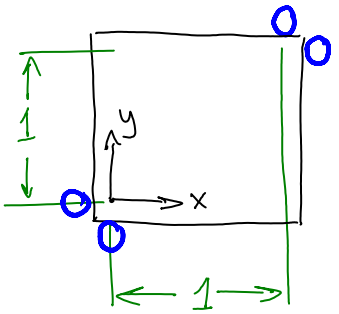
b.iii.) Can the fingers control all internal forces? Why or why not?

b.iv.) null(G) and null(J^T) represent unachievable contact

b.iv.) null(G) and null(J^T) represent unachievable contact twists on the object and hand respectively. Give a physical interpretation of these unachievable twists.

2. **2D Problem!**

25 pts



Determine analytically if the grasp has form closure.

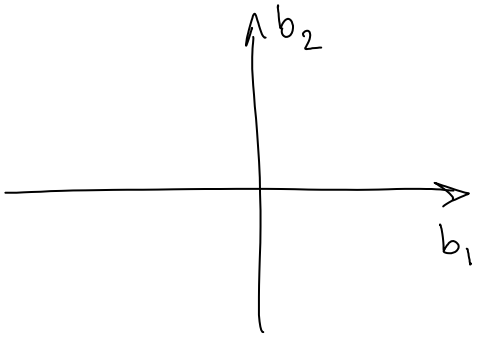
3. Given the following LCP:

25 pts

$$0 \leq \begin{bmatrix} p_1 \\ p_2 \end{bmatrix} \perp \begin{bmatrix} 1 & -1 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} p_1 \\ p_2 \end{bmatrix} + \begin{bmatrix} b_1 \\ b_2 \end{bmatrix} \geq 0$$

a.) Determine the set of $\begin{bmatrix} b_1 \\ b_2 \end{bmatrix}$ consistent with each of the 4 LCP solution cases $\left[\begin{array}{c|c|c|c} + & 0 & + & 0 \\ + & 0 & 0 & + \end{array}\right] \left[\begin{array}{c|c} 0 & + \\ + & 0 \end{array}\right] \left[\begin{array}{c|c} 0 & + \\ 0 & + \end{array}\right]$

and sketch the sets on the axes below



b. Is there at least one consistent case for each $\begin{bmatrix} b_1 \\ b_2 \end{bmatrix} \in \mathbb{R}^2$?

c. Show all $\begin{bmatrix} b_1 \\ b_2 \end{bmatrix}$ on the sketch that are consistent with more than one case.

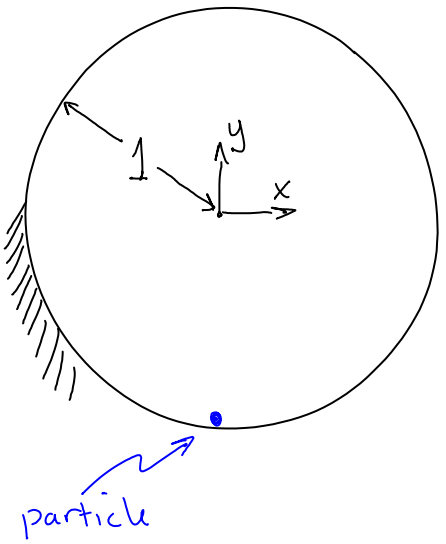
4. 2D Problem!

(25 pts)

A particle is moving inside a circular cavity in the plane.

Find the position of the particle at $t = 2$.

Using LCP time stepping, determine the positions of the particle at times $t = 1$ and $t = 2$.



Assume: $h = m = 1$, $\mu = 0$

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$$v^\circ = \begin{bmatrix} 1 \\ -1 \end{bmatrix} \qquad u^\circ = \begin{bmatrix} 0 \\ -1 \end{bmatrix} \qquad p_{ext} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

If particle isn't touching surface of circle use $\hat{n}$ at point on circle closest to particle