1) Estimate generalized coordinates  for local coordinate frames attached to the web cutter shown below. Use units of cm.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Link | 1 | 2 | 3 | 4 |
| Origin {ri} | { 0, 0 }T | { , }T | { , }T | { , }T |
| Angle  | 0 deg | 30 deg |  deg |  deg |

2) Complete the table of constant local body-fixed locations of specific points. Use units of cm.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |
| A | { , }T | { , }T |  |  |
| B |  | { , }T | { , }T |  |
| C |  |  | { , }T | { , }T |
| D | { , }T |  |  | { , }T |
| P |  |  | { , }T |  |
| Q |  |  |  | { , }T |

3) Symbolically write a constraint vector  for this mechanism. The driver constraint should start at 30 degrees and rotate at constant 60 rpm CCW for web motion from right to left.

4) Use MATLAB to compute residuals of  using values from parts 1) and 2) above. You may cut/paste code from Notes\_04\_06.

maximum abs  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

5) Symbolically write the entire Jacobian matrix .

6) Use MATLAB to evaluate the determinant of the Jacobian from part 5) using values from parts 1) and 2) above.

det  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

7) Numerically estimate the Jacobian matix  using test\_jac.m and compare to part 6).

det  using test\_jac \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

8) Replace the absolute angle driving constraint for with a relative position driving constraint between y3P and y4Q that would cut the web. Reevaluate the last row of the constraint vector and the Jacobian both symbolically and numerically. Using values from parts 1) and 2) above, compute residuals for your new driving constraint and the determinant of the Jacobian.

maximum abs  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ det  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**A2**

**B2**

**y’2**

**x’2**

**B3**

**C3**

**y’3**

**x’3**

**C4**

**D4**

**y’4**

**x’4**

**A1**

**D1**

**y’1**

**x’1**

**P3**

**Q4**

**2**

**3**

**4**

**A**

**B**

**C**

**D**

**Q**

**P**

**13.21 cm**

**2.03 cm**

**12.20 cm**

**2.03 cm**

**10.16 cm**

**7.11 cm**

**BC =**

**14.23 cm**

**AB =**

**4.00 cm**

**CD =**

**20.32 cm**

% test\_jac.m - evaluate Jacobian by numerical partial derivatives

% used for ME 581 web cutter

% HJSIII, 20.02.19

% hold estimates for generalized coordinates

nq = length(q);

qhold = q;

% evaluate constraints

wc\_phi

% hold constraints

phold = PHI;

% perturb one coordinate at a time

for iq = 1:nq,

 q = qhold;

 q(iq) = q(iq) + 0.01;

% change in constraints caused by coordinate perturbation is

% approximately equal to partial derivative

 wc\_phi

 jtest(:,iq) = ( PHI - phold ) / 0.01;

end

% reset coordinates and constraints

q = qhold;

wc\_phi

% bottom - test\_jac