

1) Estimate generalized coordinates $\{q\} = \{x_2 \ y_2 \ \phi_2 \ x_3 \ y_3 \ \phi_3 \ x_4 \ y_4 \ \phi_4\}^T$ for local coordinate frames attached to the web cutter shown below. Use units of cm.

Link	1	2	3	4
Origin $\{r_i\}$	$\{0, 0\}^T$	$\{ \quad , \quad \}^T$	$\{ \quad , \quad \}^T$	$\{ \quad , \quad \}^T$
Angle ϕ_i	0 deg	30 deg	deg	deg

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

	$\{s_1\}'$	$\{s_2\}'$	$\{s_3\}'$	$\{s_4\}'$
A	$\{ \quad , \quad \}^T$	$\{ \quad , \quad \}^T$		
B		$\{ \quad , \quad \}^T$	$\{ \quad , \quad \}^T$	
C			$\{ \quad , \quad \}^T$	$\{ \quad , \quad \}^T$
D	$\{ \quad , \quad \}^T$			$\{ \quad , \quad \}^T$
P			$\{ \quad , \quad \}^T$	
Q				$\{ \quad , \quad \}^T$

3) Symbolically write a constraint vector $\{\Phi\}$ for this mechanism. The driver constraint should start ϕ_2 at 30 degrees and rotate at constant 60 rpm CCW for web motion from right to left.

4) Use MATLAB to compute residuals of $\{\Phi\}$ using values from parts 1) and 2) above. You may cut/paste code from Notes_04_06.

maximum abs $\{\Phi\}$ _____

5) Symbolically write the entire Jacobian matrix $[\Phi_q]$.

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

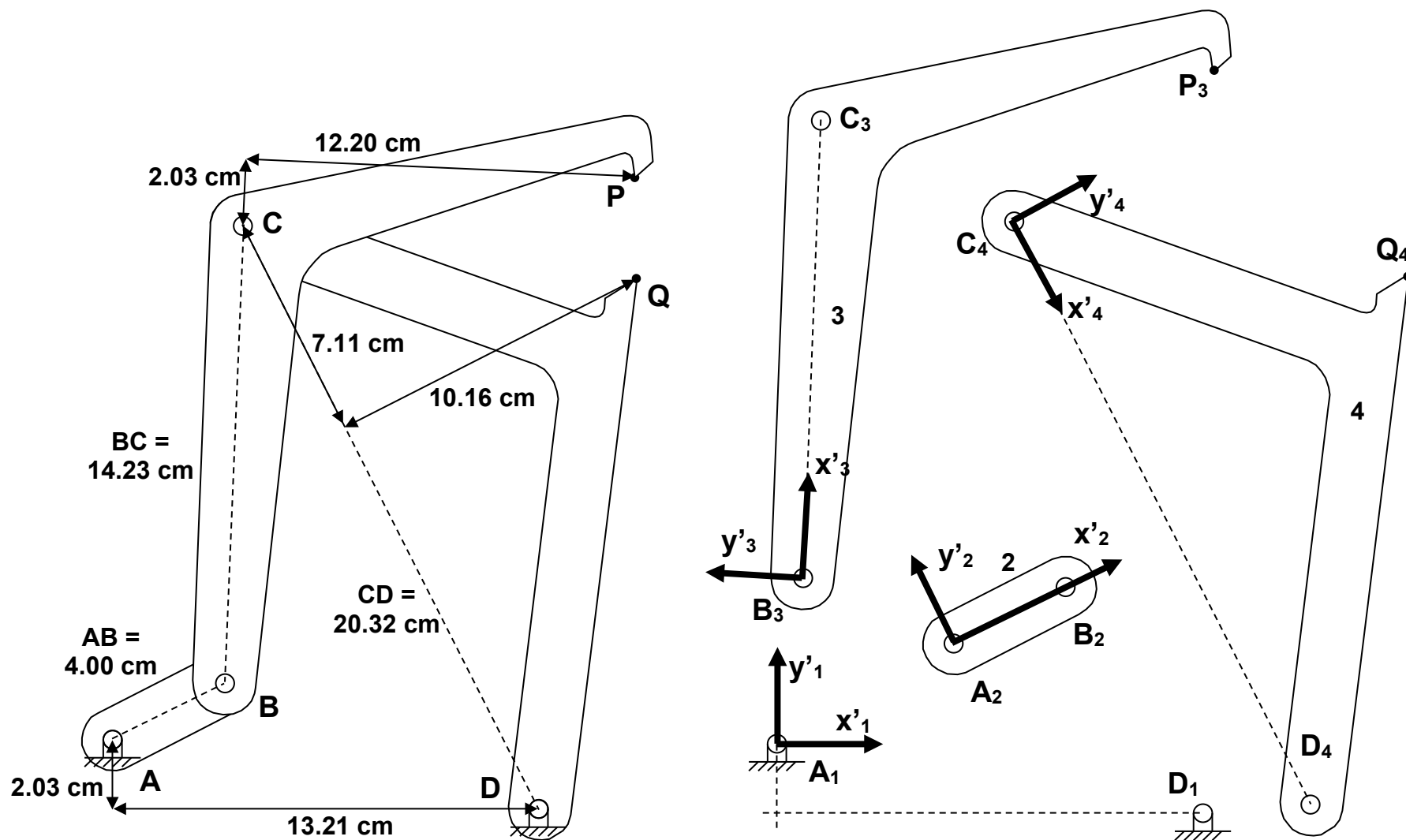
det $[\Phi_q]$ _____

7) Numerically estimate the Jacobian matrix $[\Phi_q]$ using test_jac.m and compare to part 6).

det $[\Phi_q]$ using test_jac _____

8) Replace the absolute angle driving constraint for ϕ_2 with a relative position driving constraint between y_3^P and y_4^Q 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 $\{\Phi\}$ _____ det $[\Phi_q]$ _____



```
% 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
```