ME 581 – C03 **Name** _____

1) Use the full size image of link 3 for the web cutter provided below to calculate mass, centroid location and centroidal polar mass moment of inertia using classical geometric methods. Provide $\{s_3\}'^{G}$ relative to the coordinate frame used for C01. The link is made of 1 cm thick aluminum.
Show your work and units.

m_3 167.31 g $\{s_3\}'^{G}$ $\{10.09 \text{ cm}, -2.45 \text{ cm}\}^T$ J_{G3}' 7.479 kg.cm^2

2) Use boundary summations to approximate mass, centroid location and centroidal polar mass moment of inertia for each link in the web cutter. Scaled outlines for all three links are available in "wc_link%.txt" on our class web page. The outlines have been aligned with coordinate frames used for C01. Links are made of 1 cm thick aluminum.

Link	2	3	4	
Mass m	30.82	159.62	151.80	g
Centroid $\{s_i\}'^{G}$	$\{2, 0\}^T$	$\{10.50, -2.35\}^T$	$\{9.80, 3.90\}^T$	cm
Polar moment J_{Gi}'	0.091	6.448	6.808	kg.cm^2

3) How do your geometric calculations compare to boundary integral results?

4) Relocate local coordinate frames to the centroids of the links and repeat the plots requested for C02. Angular velocities and angular accelerations of the links should remain the same. You need not repeat any work for speed of the web.

ESTIMATED GLOBAL POSE OF COORDINATE FRAMES

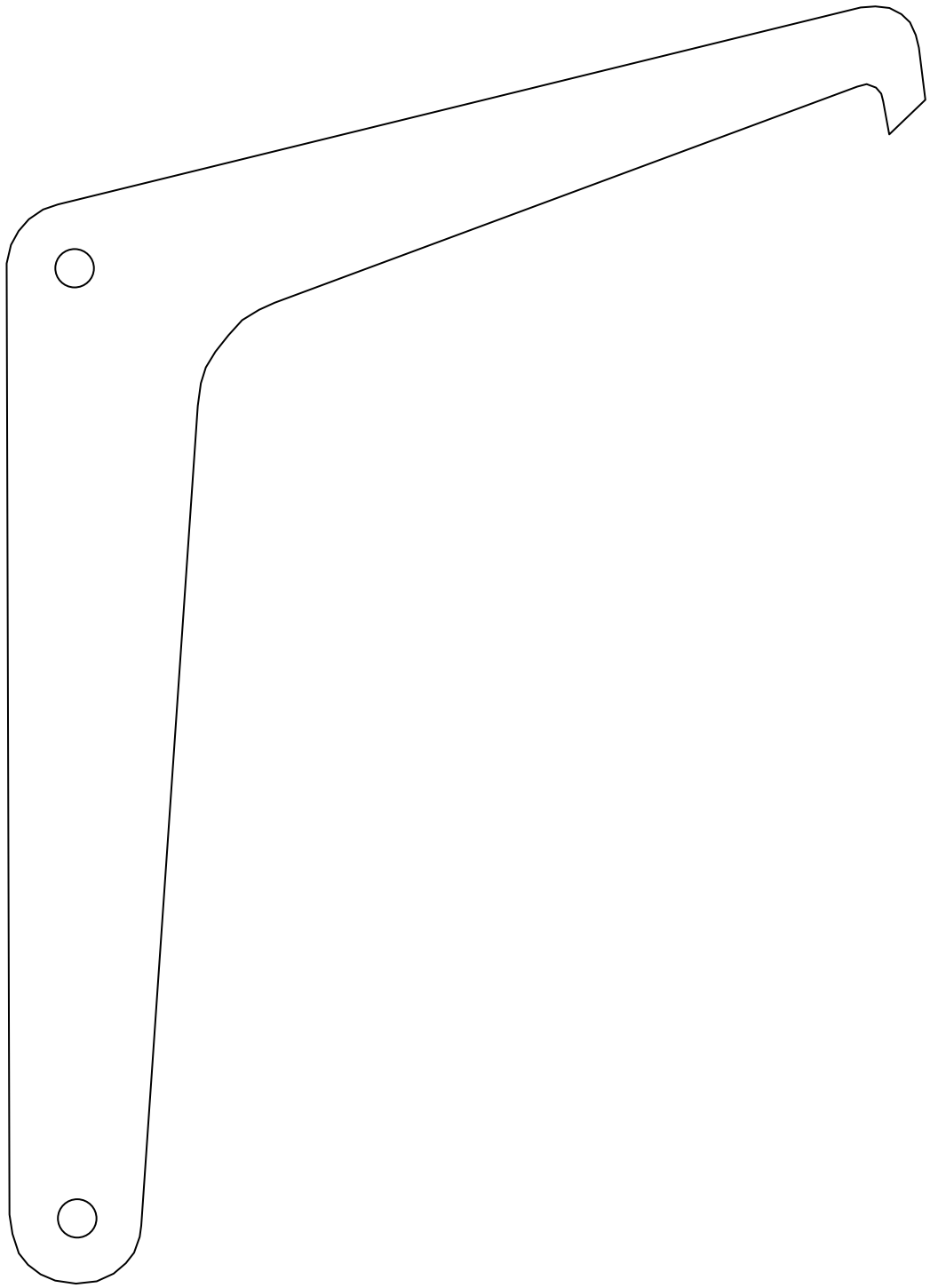
Link	1	2	3	4
Origin $\{r_i\}$	$\{0, 0\}^T$	$\{1.75, 1\}^T$	$\{6, 12\}^T$	$\{12, 9\}^T$
Angle ϕ_i	0 deg	30 deg	90 deg	-60 deg

CONSTANT LOCAL BODY-FIXED LOCATIONS OF SPECIFIC POINTS

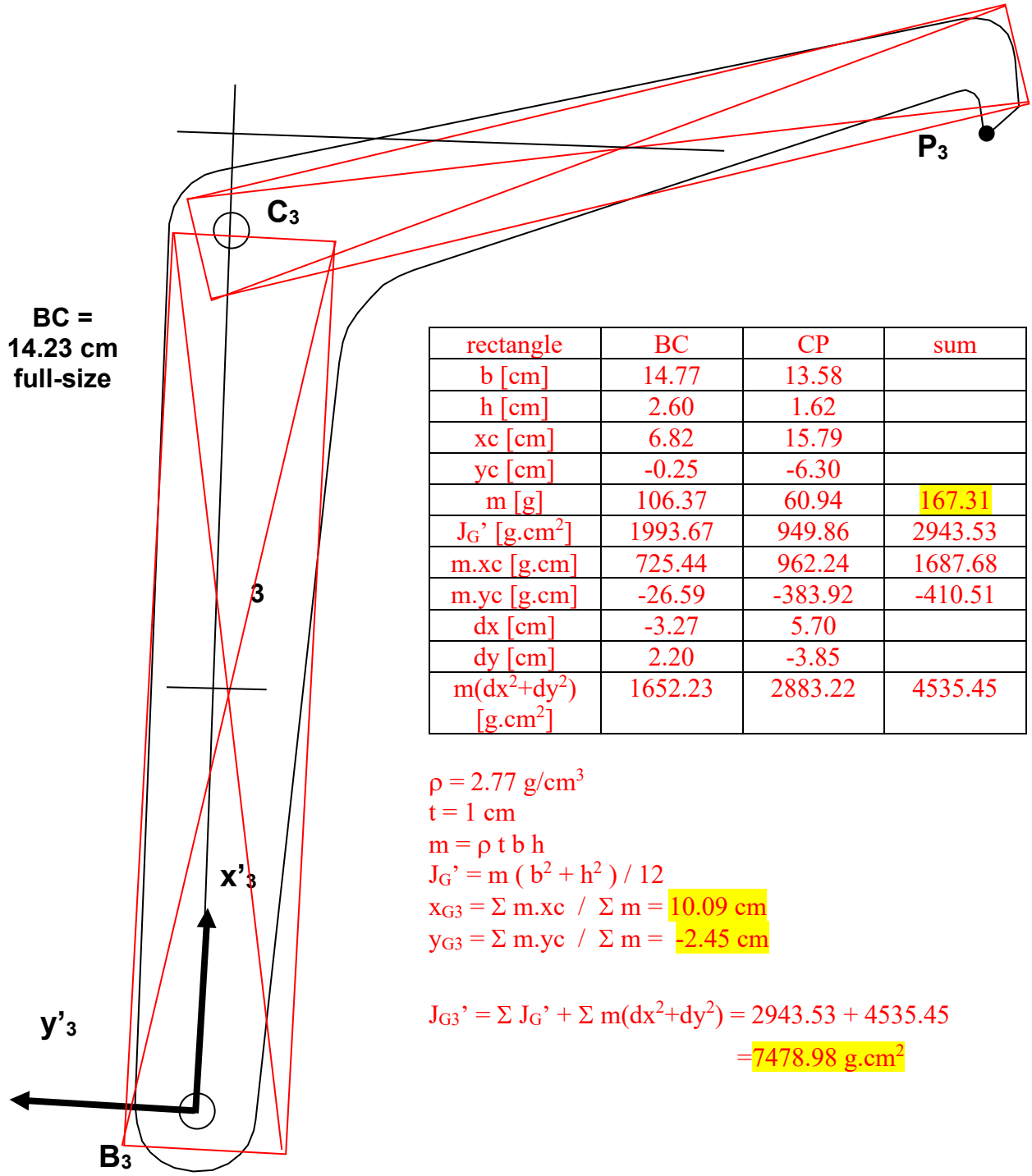
	$\{s_1\}'$	$\{s_2\}'$	$\{s_3\}'$	$\{s_4\}'$
A	$\{0, 0\}^T$	$\{-2, 0\}^T$		
B		$\{2, 0\}^T$	$\{-10.50, 2.35\}^T$	
C			$\{3.73, 2.35\}^T$	$\{-9.80, -3.90\}^T$
D	$\{13.21, -2.03\}^T$			$\{10.52, -3.90\}^T$
P			$\{5.76, -9.85\}^T$	
Q				$\{-2.69, 6.26\}^T$

ME 581 – C03 **Name** _____

1ink 3 - full size



ME 581 – C03 **Name** _____

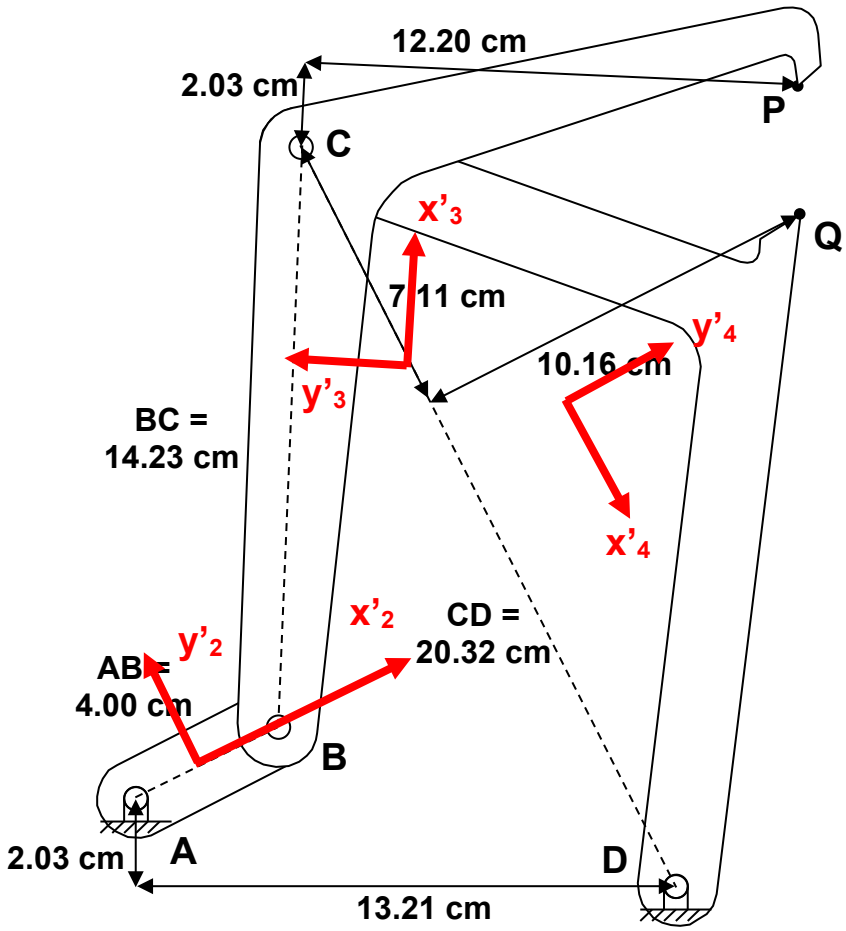


rectangle	BC	CP	sum
b [cm]	14.77	13.58	
h [cm]	2.60	1.62	
xc [cm]	6.82	15.79	
yc [cm]	-0.25	-6.30	
m [g]	106.37	60.94	167.31
J_G' [g.cm^2]	1993.67	949.86	2943.53
m.xc [g.cm]	725.44	962.24	1687.68
m.yc [g.cm]	-26.59	-383.92	-410.51
dx [cm]	-3.27	5.70	
dy [cm]	2.20	-3.85	
m(dx^2+dy^2) [g.cm^2]	1652.23	2883.22	4535.45

$\rho = 2.77$ g/cm^3
$t = 1$ cm
$m = \rho\, t\, b\, h$
$J_G' = m\,(b^2 + h^2)\,/\,12$
$x_{G3} = \Sigma\, m.xc \;/\; \Sigma\, m = 10.09$ cm
$y_{G3} = \Sigma\, m.yc \;/\; \Sigma\, m = -2.45$ cm

$J_{G3}' = \Sigma\, J_G' + \Sigma\, m(dx^2+dy^2) = 2943.53 + 4535.45$
$= 7478.98$ g.cm^2

ME 581 – C03 **Name** _____




```
>> wc_geom_c03

Link 2
      area     X_cen     Y_cen    J/1000      mass    Jprime
    [cm^2]      [cm]      [cm]    [cm^4]       [g] [kg.cm^2]
   11.1256    2.0000    0.0000    0.0327   30.8179    0.0905

Link 3 - no holes
      area     X_cen     Y_cen    J/1000      mass    Jprime
    [cm^2]      [cm]      [cm]    [cm^4]       [g] [kg.cm^2]
   58.5938   10.4448   -2.3070    2.3930  162.3050    6.6286

Link 3 - with holes
      area     X_cen     Y_cen    J/1000      mass    Jprime
    [cm^2]      [cm]      [cm]    [cm^4]       [g] [kg.cm^2]
   57.6243   10.5008   -2.3458    2.3277  159.6193    6.4477

Link 4
      area     X_cen     Y_cen    J/1000      mass    Jprime
    [cm^2]      [cm]      [cm]    [cm^4]       [g] [kg.cm^2]
   54.8015    9.8044    3.8961    2.4577  151.8003    6.8078
```

ME 581 – C03 **Name _____**

```
% wc_geom_c03.m - web-cutter four-bar for ME 581
%   link inertial properties
% HJSIII, 20.03.04

% constants
t = 1;              % thickness [cm]
density = 2.77;     % density for aluminum [g/cm^3]

% link 2
disp( ' ' )
disp( 'Link 2' )
xy = load( 'wc_link2.txt' );
[ g, i, c ] = polygeom( xy(:,1), xy(:,2) );
J = c(5)/1000;
mass = g(1) * t * density;
Jprime = J * t * density;
disp( '      area     X_cen     Y_cen    J/1000      mass    Jprime' )
disp( '     [cm^2]      [cm]      [cm]    [cm^4]       [g] [kg.cm^2]' )
disp( [ g(1:3)  J  mass  Jprime ] )

figure( 1 )
  clf
  plot( xy(:,1), xy(:,2) )
  axis( [ -5 25  -15 15 ] )
  axis square
  hold on

% link 3 - no holes
disp( 'Link 3 - no holes' )
xy = load( 'wc_link3.txt' );
[ g, i, c ] = polygeom( xy(:,1), xy(:,2) );
J = c(5)/1000;
mass = g(1) * t * density;
Jprime = J * t * density;
disp( '      area     X_cen     Y_cen    J/1000      mass    Jprime' )
disp( '     [cm^2]      [cm]      [cm]    [cm^4]       [g] [kg.cm^2]' )
disp( [ g(1:3)  J  mass  Jprime ] )

  plot( xy(:,1), xy(:,2) )

% link 3 - with holes
disp( 'Link 3 - with holes' )
xyB = load( 'wc_link3_holeB.txt' );
xyC = load( 'wc_link3_holeC.txt' );
xy = [ xy ; xyB ; xy(1,:) ; xyC ];
[ g, i, c ] = polygeom( xy(:,1), xy(:,2) );
J = c(5)/1000;
mass = g(1) * t * density;
Jprime = J * t * density;
disp( '      area     X_cen     Y_cen    J/1000      mass    Jprime' )
disp( '     [cm^2]      [cm]      [cm]    [cm^4]       [g] [kg.cm^2]' )
disp( [ g(1:3)  J  mass  Jprime ] )

% link 4
disp( 'Link 4' )
xy = load( 'wc_link4.txt' );
[ g, i, c ] = polygeom( xy(:,1), xy(:,2) );
J = c(5)/1000;
mass = g(1) * t * density;
Jprime = J * t * density;
disp( '      area     X_cen     Y_cen    J/1000      mass    Jprime' )
disp( '     [cm^2]      [cm]      [cm]    [cm^4]       [g] [kg.cm^2]' )
disp( [ g(1:3)  J  mass  Jprime ] )

  plot( xy(:,1), xy(:,2) )

% bottom - wc_geom_c03
```

ME 581 – C03 **Name _____**

Verified graphs as C02 using same code for
wc_main_c02.m EXCEPT calls wc_ini_c03.m
wc_phi.m
wc_kin.m

```
% wc_ini_c03.m - web cutter four-bar for ME 581
%   initialize constants and assembly guesses
%   coordinate frames shifted to centroids
% HJSIII, 20.03.04

% mechanism constants
len2 = 4;
len3 = 14.23;
len4 = 20.32;

s1pA = [ 0    0 ]';
s1pD = [ 13.21  -2.03 ]';

s2pA = [ 0  0 ]';
s2pB = [ len2  0 ]';

s3pB = [ 0  0 ]';
s3pC = [ len3  0 ]';
s3pP = [ 16.26  -12.20 ]';

s4pC = [ 0  0 ]';
s4pD = [ len4  0 ]';
s4pQ = [ 7.11  10.16 ]';

% shift local frames to centroids
s2pG = [  2      0    ]';
s3pG = [ 10.50  -2.35 ]';
s4pG = [ 9.80    3.90 ]';

s2pA = s2pA - s2pG;
s2pB = s2pB - s2pG;

s3pB = s3pB - s3pG;
s3pC = s3pC - s3pG;
s3pP = s3pP - s3pG;

s4pC = s4pC - s4pG;
s4pD = s4pD - s4pG;
s4pQ = s4pQ - s4pG;

% NEW initial guesses estimated by eye
phi2 =  30 * d2r;
phi3 =  90 * d2r;
phi4 = -60 * d2r;

q(1,1) = 1.75;
q(2,1) = 1;
q(3,1) = phi2;

q(4,1) = 6;
q(5,1) = 12;
q(6,1) = phi3;

q(7,1) = 12;
q(8,1) = 9;
q(9,1) = phi4;

% driver for crank - phi2 = phi2_start + w2*t
phi2_start = 30 * d2r;
w2 = +60 * 2 * pi / 60;   % 60 rpm CCW, convert to rad/sec

% bottom - wc_ini_c03
```