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1) Determine mass and centroidal mass moment of inertia for an aluminum bar that is 4 cm wide, 25 cm long and 2 cm thick. Then create a Working Model (WM) link and adjust the mass in the "Properties" window to represent the actual link. Working Model assumes that all links are planar and are one unit thick. Validate your approach by repeating for an aluminum circular disk with 15 cm diameter and 2 cm thickness. Use units of [kg] for mass and [kg.cm^2] for mass moment of inertia.

	4 x 25 x 2 cm bar	15 cm OD x 2 cm disk
actual density	2.714 g/cm^3 (6061 alum)	2.714 g/cm^3
mass	0.5428 kg	0.9591 kg
centroidal J	28.995 kg.cm^2	26.975 kg.cm^2
WM mass	0.542 kg	0.959 kg
WM centroidal J	29.005 kg.cm^2	26.972 kg.cm^2
WM density	0.005 kg/cm^3	0.005 kg/cm^3

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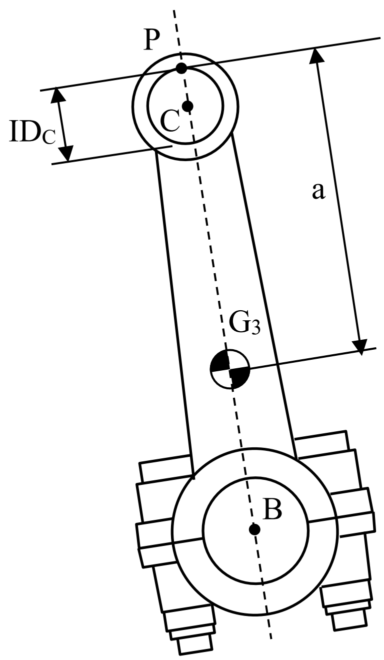
2) A connecting rod 3 from an air compressor was weighed and measured as shown below. The connecting rod was balanced on a straight edge to find its centroid location G_3. It was then suspended by the inner surface of the wrist pin at point P and allowed to swing freely with small angle motion. Twenty periods of oscillation were measured. These measurements were repeated ten times.

m_3 = 0.462 lbm   L = BC = 4.33 inch   a = 3.642 inch ID_C = 0.707 inch

$20\ \tau$ = 13.69 13.67 13.64 13.67 13.66 13.76 13.74 13.73 13.79 13.67 sec

Determine time period τ, standard deviation σ_τ and centroidal mass moment of inertia J_{G3}.

τ 0.6851 sec σ_τ 0.002481 sec $100\ \sigma_\tau / \tau$ 0.363 % J_{G3} 1.596 lbm.in^2



$J_G = m\ g\ a\ \tau^2 / 4\ \pi^2 - m\ a^2$
$= 7.724$ lbm.in^2 – 6.128 lbm.in^2
$= 1.596$ lbm.in^2

3) Determine BG_3 and CG_3. Then use the two-mass equivalent link model to find lumped masses m_{3B} and m_{3C} and the approximate lumped mass moment of inertia J_{APP}.

BG_3 1.043 inch CG_3 3.288 inch m_{3B} 0.351 lbm m_{3C} 0.111 lbm J_{APP} 1.582 lbm.in^2

$CG_3 = a - ID_C / 2 = 3.388$ inch $BG_3 = BC - CG_3 = 1.043$ inch

$$m_{3B} = m_3 \frac{CG_3}{BC} = 0.351 \text{ lbm} \qquad m_{3C} = m_3 \frac{BG_3}{BC} = 0.111 \text{ lbm}$$

$$J_{G3\_APP} = m_{3B}(BG_3)^2 + m_{3C}(CG_3)^2 = 1.582 \text{ lbm.in}^2$$

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4) Use "polygeom" boundary summations to approximate mass, centroid location and centroidal polar mass moment of inertia for the connecting rod assuming it is made of 0.75 inch thick flat aluminum plate. Outlines for the connecting rod and holes are available in "h10_conn_rod_CCW.txt", "h10_holeB_CCW.txt" and "h10_holeC_CCW.txt" on our class web page. Note that all three outlines were digitized CCW. Provide a plot of your outlines with a small red cross at the centroid location and attach hard copy of your code.

m_3 0.520 lbm BG_3 1.346 inch $J_{BOUNDARY}$ 1.481 lbm.in^2

5) Compare your experimental measurements, lumped mass approximations and flat plate boundary approximations for mass, centroid location and mass moment of inertia.

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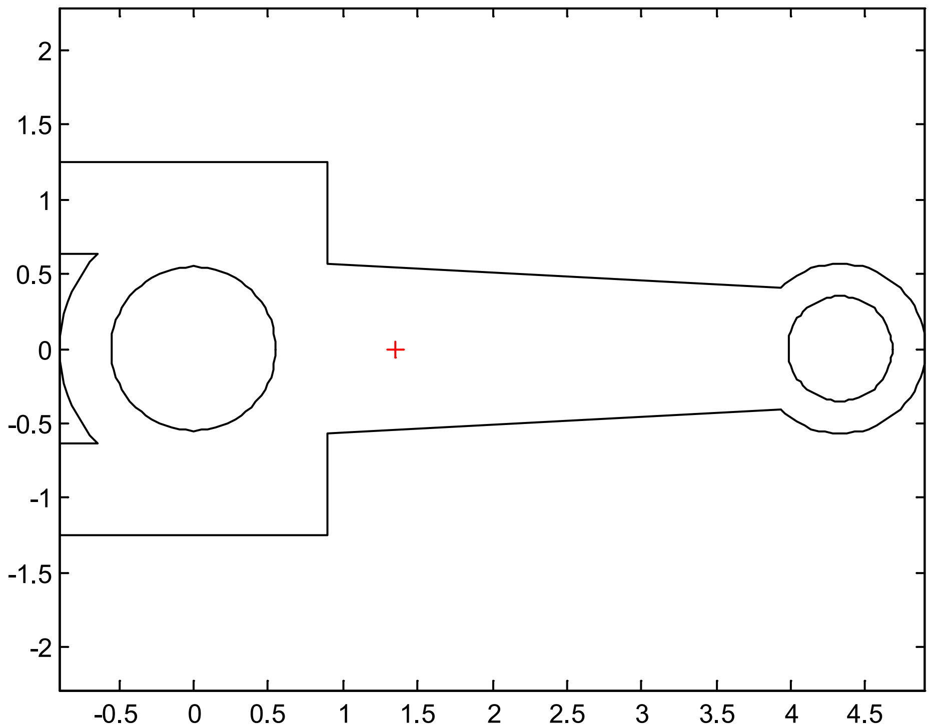


```
% h10_01.m - area, centroid, mass moment for conn rod - ME 481
% HJSIII, 16.03.02

clear

% constants
d2r = pi / 180;

% density and thickness
rho = 0.1;          % density [lbm/in^3]
t = 0.75;           % thickness [inch]

% read outlines from text files - units= [inch]
outer = load( 'h10_conn_rod_CCW.txt' );
holeB = load( 'h10_holeB_CCW.txt' );
holeC = load( 'h10_holeC_CCW.txt' );

% rip into row vectors and make holes CW
x_outer = outer(:,1)';
y_outer = outer(:,2)';

x_holeB = fliplr( holeB(:,1)' );
y_holeB = fliplr( holeB(:,2)' );

x_holeC = fliplr( holeC(:,1)' );
y_holeC = fliplr( holeC(:,2)' );

% check plot
figure( 1 )
  clf
  plot( x_outer,y_outer,'k', x_holeB,y_holeB,'k', x_holeC,y_holeC,'k' )
  axis equal
```

```
% assemble outline and holes
x_all = [ x_outer  x_holeB  x_outer(1)  x_holeC  x_outer(1) ];
y_all = [ y_outer  y_holeB  y_outer(1)  y_holeC  y_outer(1) ];

% area, centroid, area moment about centroid
[ geom, iner, cpmo ] = polygeom( x_all, y_all );
area   = geom(1);  % [in^2]
x_cen  = geom(2);  % [in]
y_cen  = geom(3);  % [in]
J_area = cpmo(5);  % [in^4]

% plot centroid
  hold on
  plot( x_cen, y_cen, 'r+' )

% mass and mass moment
m = rho * t * area;     % [lbm]
Jg = rho * t * J_area;  % [lbm.in^2]

m
x_cen
y_cen
Jg

% bottom of h10_01.m
```