Project (#4): Properties of Thin-Wall General and Airfoil Cross-Sections Due Date: Upload zip folder to TED by 11:58 PM, Friday, March 13, 2020

Files that you need in your MATLAB Folder:

SE160A 4 Section Input.xlsx **Download from TED: Download from TED:** SE160A_4_Section_Output.xlsx

SE160A_4_Section.p **Download from TED: Download from TED:** createFigure.m **Download from TED:** deleteFigure.m

Your created (m) file: For Undergraduate Students: SE160A 4 LastName FirstName.m

For Graduate Students: SE260A 4 LastName FirstName.m

Problem Answers are saved in a (pdf):

For Undergraduate Students: SE160A 4 LastName FirstName.pdf For Graduate Students: SE260A_4_LastName_FirstName.pdf

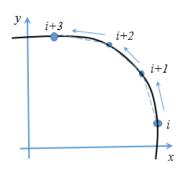
Upload your (m) file and (pdf) file into a (zip) folder of the same name: For Undergraduate Students: SE160A_4_LastName_FirstName.zip For Graduate Students: SE260A 4 LastName FirstName.zip

Introduction

Aerospace structures are built-up from a wide variety of structural components (stringers, longerons, skins, etc.). The analysis of these structures requires that the section properties are known. In this MATLAB assignment, you will write a computer program that calculates the section properties of a general (arbitrary) cross-section that is composed of thin-wall straight "skin" segments and/or discrete "stringer" elements. In addition, you will calculate the section properties of a thin wall airfoil (NACA four series) with internal spars.

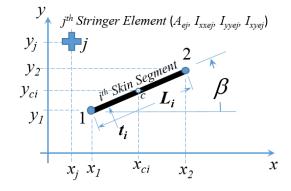
General Section

The curved skin is divided into straight segments that are defined using the (x,y)coordinate points at the segment ends, along with the skin thickness (t), density (ρ) , and Young's modulus (E). The discrete stringer elements are defined using their section properties (A_e , I_{xxe} , I_{yye} , I_{xye}) in their own local element frame along with the (x,y) coordinate location to the stringer element centroid and material properties (ρ, E) .



The *calculated section properties* in this initial coordinate frame (x,y) include

the structural area (A), centroid location (x_c , y_c), and the inertia (I_{xx} , I_{yy} , I_{xy}) properties. In addition, the massweighted and modulus-weighted section properties are calculated in this initial frame. Next, all of the above section properties are calculated in the centroidal axis frame (origin moved to area centroid), then in the modulus-weighted axis frame (origin moved to modulus-weighted area centroid), and finally in a user defined location (x_0, y_0) . All of these cross-section properties are calculated by making use of the parallel axis theorem. You will solve this problem by discretizing the arbitrary open or closed cell thin-wall cross-section into a series of straight skin segments along with the addition of discrete stringer elements, where the segments are defined in a counter clockwise order around the section. Internal spars can be treated by additional skin elements.



The curved skin is divided into straight segments that are defined using the (x,y) coordinate points at the segment ends, along with the skin thickness (t), density (ρ) , and Young's modulus (E). The discrete stringer elements are defined using their section properties $(A_e, I_{xxe}, I_{yye}, I_{xye})$ in their own local element frame along with the (x,y) coordinate location to the stringer element centroid and material properties (ρ, E) .

NACA 4-Digit Airfoil Section

A 4-digit system of identifying standard airfoils was developed by NACA (National Advisory Committee for Aeronautics; the predecessor of NASA) in the 1930's, and both the system and the airfoils they represent are still used today in aircraft wings, tail sections, helicopter blades, and propellers. The first two digits (M and P) define the camber line, and the second two digits (TT) define the maximum thickness of the airfoil. It is a relatively simple system to program and use, and this family of airfoils provides an excellent medium for studying the effects of an airfoil's thickness and camber on its structural behavior. The equations for the four-digit definition are used to generate the linear skin segments. Internal vertical spars are defined at specific chord locations that connect the lower and upper skin. All of the skin segments are then used to determine the airfoil's cross-sectional properties in the original frame, centroidal frame, modulus-weighted frame, and the user-defined coordinate frame. The equations for the cambered airfoil are given in the appendix.

Cross-Section Properties

The section properties for the (i^{th}) straight skin segment about the initial coordinate frame (x, y) are given by:

$$\begin{split} L_{i} &= \sqrt{\left(x_{2} - x_{1}\right)^{2} + \left(y_{2} - y_{1}\right)^{2}} \\ x_{c_{i}} &= \frac{1}{2}\left(x_{1} + x_{2}\right) \\ y_{c_{i}} &= \frac{1}{2}\left(y_{1} + y_{2}\right) \\ I_{xx_{i}} &= \frac{t_{i}L_{i}^{3}}{12}\sin^{2}\beta + A_{i}y_{c_{i}}^{2} = \frac{A_{i}}{6}\left(y_{1}\left(2y_{1} + y_{2}\right) + y_{2}\left(y_{1} + 2y_{2}\right)\right) \\ I_{yy_{i}} &= \frac{t_{i}L_{i}^{3}}{12}\cos^{2}\beta + A_{i}x_{c_{i}}^{2} = \frac{A_{i}}{6}\left(x_{1}\left(2x_{1} + x_{2}\right) + x_{2}\left(x_{1} + 2x_{2}\right)\right) \\ I_{xy_{i}} &= \frac{t_{i}L_{i}^{3}}{12}\cos\beta\sin\beta + A_{i}x_{c_{i}}y_{c_{i}} = \frac{A_{i}}{6}\left(x_{1}\left(2y_{1} + y_{2}\right) + x_{2}\left(y_{1} + 2y_{2}\right)\right) \end{split}$$

The properties of the total cross-section are determined by simply summing the properties for all the (i^{th}) straight skin segments and all the (j^{th}) stringer elements.

$$A = \sum_{i=1}^{n_{s}} A_{s_{i}} + \sum_{j=1}^{n_{e}} A_{e_{j}}$$

$$I_{xx} = \sum_{i=1}^{n_{s}} I_{xxi} + \sum_{j=1}^{n_{e}} \left(I_{xxej} + A_{e_{j}} \left(y_{e_{j}} \right)^{2} \right)$$

$$X_{c} = \frac{1}{A} \left(\sum_{i=1}^{n_{s}} A_{s_{i}} x_{c_{i}} + \sum_{j=1}^{n_{e}} A_{e_{j}} x_{e_{j}} \right)$$

$$I_{yy} = \sum_{i=1}^{n_{s}} I_{yyi} + \sum_{j=1}^{n_{e}} \left(I_{yyej} + A_{e_{j}} \left(x_{e_{j}} \right)^{2} \right)$$

$$Y_{c} = \frac{1}{A} \left(\sum_{i=1}^{n_{s}} A_{s_{i}} y_{c_{i}} + \sum_{j=1}^{n_{e}} A_{e_{j}} y_{e_{j}} \right)$$

$$I_{xy} = \sum_{i=1}^{n_{s}} I_{xyi} + \sum_{j=1}^{n_{e}} \left(I_{xyej} + A_{e_{j}} \left(x_{e_{j}} y_{e_{j}} \right) \right)$$

The mass-weighted properties of the total cross-section are determined by summing the product of the densities multiplied by the straight skin segments and the product of the densities multiplied by the stringer elements.

$$\rho A = \sum_{i=1}^{n_s} \rho_i A_{s_i} + \sum_{j=1}^{n_e} \rho_j A_{e_j}$$

$$\rho I_{xx} = \sum_{i=1}^{n_s} \rho_i I_{xxi} + \sum_{j=1}^{n_e} \rho_j \left(I_{xxej} + A_{e_j} \left(y_{e_j} \right)^2 \right)$$

$$x_{cg} = \frac{1}{\rho A} \left(\sum_{i=1}^{n_s} \rho_i A_{s_i} x_{c_i} + \sum_{j=1}^{n_e} \rho_j A_{e_j} x_{e_j} \right)$$

$$\rho I_{yy} = \sum_{i=1}^{n_s} \rho_i I_{yyi} + \sum_{j=1}^{n_e} \rho_j \left(I_{yyej} + A_{e_j} \left(x_{e_j} \right)^2 \right)$$

$$y_{cg} = \frac{1}{\rho A} \left(\sum_{i=1}^{n_s} \rho_i A_{s_i} y_{c_i} + \sum_{j=1}^{n_e} \rho_j A_{e_j} y_{e_j} \right)$$

$$\rho I_{xy} = \sum_{i=1}^{n_s} \rho_i I_{xyi} + \sum_{j=1}^{n_e} \rho_j \left(I_{xyej} + A_{e_j} \left(x_{e_j} \right)^2 \right)$$

$$\rho I_{xy} = \sum_{i=1}^{n_s} \rho_i I_{xyi} + \sum_{j=1}^{n_e} \rho_j \left(I_{xyej} + A_{e_j} \left(x_{e_j} \right)^2 \right)$$

The modulus-weighted properties of the total cross-section are determined by summing the product of the Young's moduli multiplied by the straight skin segments and the product of the Young's moduli multiplied by the stringer elements.

$$EA = \sum_{i=1}^{n_{s}} E_{i} A_{s_{i}} + \sum_{j=1}^{n_{e}} E_{j} A_{e_{j}}$$

$$EI_{xx} = \sum_{i=1}^{n_{s}} E_{i} I_{xxi} + \sum_{j=1}^{n_{e}} E_{j} \left(I_{xxej} + A_{e_{j}} \left(y_{e_{j}} \right)^{2} \right)$$

$$x_{EA} = \frac{1}{EA} \left(\sum_{i=1}^{n_{s}} E_{i} A_{s_{i}} x_{c_{i}} + \sum_{j=1}^{n_{e}} E_{j} A_{e_{j}} x_{e_{j}} \right)$$

$$EI_{yy} = \sum_{i=1}^{n_{s}} E_{i} I_{yyi} + \sum_{j=1}^{n_{e}} E_{j} \left(I_{yyej} + A_{e_{j}} \left(x_{e_{j}} \right)^{2} \right)$$

$$y_{EA} = \frac{1}{EA} \left(\sum_{i=1}^{n_{s}} E_{i} A_{s_{i}} y_{c_{i}} + \sum_{j=1}^{n_{e}} E_{j} A_{e_{j}} y_{e_{j}} \right)$$

$$EI_{xy} = \sum_{i=1}^{n_{s}} E_{i} I_{xyi} + \sum_{j=1}^{n_{e}} E_{j} \left(I_{xyej} + A_{e_{j}} \left(x_{e_{j}} y_{e_{j}} \right) \right)$$

Once the properties are known about the origin, then the parallel axis theorem can be used to determine the section properties about the centroid, or the modulus-weighted centroid, or the user-defined location (x_0, y_0) . For example, the area inertia properties about the centroid are:

$$I_{xxc} = I_{xx} - Ay_c^2$$
 $I_{yyc} = I_{yy} - Ax_c^2$ $I_{xyc} = I_{xy} - Ax_c y_c$

and about a user defined location (x_0, y_0) ;

$$I_{xxo} = I_{xxc} + A(y_o - y_c)^2$$
 $I_{yyo} = I_{yyc} + A(x_o - x_c)^2$ $I_{xyo} = I_{xyc} + A(x_o - x_c)(y_o - y_c)$

This approach can be used to transform the mass- and modulus-weighted properties to different locations within the cross-section.

Appendix: NACA 4-Digit Airfoils

The outer profile of these airfoils is defined as the linear of sum of the functions defining (1) a symmetric (uncambered) airfoil representing minimum drag, and (2) a camber line representing maximum lift. The NACA 4-Digit airfoil is defined as:

$$NACA - MPTT$$

where, (M) and (P) define the camber line using two quadratic equations and (TT) defines the maximum thickness of the symmetric (uncambered) airfoil shape in percent of the chord. Here (M) defines the maximum camber (vertical displacement from the chord) in percent of the chord, and (P) defines the (x) location of the maximum camber in tenths of the chord. Stating;

$$\text{max vertical camber} = c \left(\frac{M}{100} \right) \qquad \text{x-location of max camber} = c \left(\frac{P}{10} \right) \qquad \text{max airfoil thickness} = c \left(\frac{TT}{100} \right)$$

where (c) is the airfoil chord length.

The COMPLETE AIRFOIL SHAPE is given as the summation (for the upper surface) and the difference (for the lower surface) of the CAMBER LINE and SYMMETRIC AIRFOIL LINE:

$$y_a = y_c \pm y_s$$

where; the SYMMETRIC AIRFOIL is defined by the following function:

$$y_{s} = 5c \left(\frac{TT}{100}\right) \left\{ .2969 \sqrt{\frac{x}{c}} - .126 \left(\frac{x}{c}\right) - .3516 \left(\frac{x}{c}\right)^{2} + .2843 \left(\frac{x}{c}\right)^{3} - .1015 \left(\frac{x}{c}\right)^{4} \right\}$$

and c is the chord length and the maximum airfoil thickness is $t_{max} = c(TT/100)$.

The CAMBER LINE is defined by two quadratic equations: one defining the camber line from the leading edge to the point of maximum camber, and another defining the camber line from the point of maximum camber to the trailing edge. The coefficients A, B, and C of these two quadratic polynomials can be found by applying the boundary conditions of continuity and zero slope where the functions intersect and setting the function value to zero at the leading and trailing edges. In other words, the CAMBER LINE is determined to be

$$y_c = c \left\{ -\frac{M}{P^2} \left(\frac{x}{c} \right)^2 + \frac{M}{5P} \left(\frac{x}{c} \right) \right\}$$

$$= \frac{cM}{100 - 20P + P^2} \left\{ -\left(\frac{x}{c} \right)^2 + \frac{P}{5} \left(\frac{x}{c} \right) + \left(1 - \frac{P}{5} \right) \right\}$$

$$(0 \le x < x_{\text{max camber}})$$

$$(x_{\text{max camber}} \le x < c)$$

Thin-Wall Section Check Cases

Cross section	Area	Centroid	Inertia
8.4 Thin Hollow Rectangle z t b c	A = 2t(a+b)	$y_C = \frac{a}{2}$ $z_C = \frac{b}{2}$	$I_{yy_c} = \frac{tb^2}{2} \left(a + \frac{b}{3} \right)$ $I_{zz_c} = \frac{ta^2}{2} \left(b + \frac{a}{3} \right)$
8.7 Thin L-Section t ₁ t ₂ t ₂ t ₂ t ₂ t ₂	$A = h_1 t_1 + h_2 t_2$	$y_{c} = \frac{1}{2} \frac{\left(h_{1}t_{1}^{2} + h_{2}^{2}t_{2}\right)}{\left(h_{1}t_{1} + h_{2}t_{2}\right)}$ $z_{c} = \frac{1}{2} \frac{\left(h_{1}^{2}t_{1} + h_{2}t_{2}\right)}{\left(h_{1}t_{1} + h_{2}t_{2}\right)}$	
8.8 Thin U-Channel z h ₂ t ₂ h ₁ t ₂	$A = h_1 t_1 + 2h_2 t_2$	$y_{c} = \frac{\left(h_{1}t_{1}^{2} + 2h_{2}^{2}t_{2}\right)}{2\left(h_{1}t_{1} + h_{2}t_{2}\right)}$ $z_{c} = 0$	

Design Studies

Using your MATLAB program and the four provided EXCEL files calculate the section properties (A, X_c , Y_c , I_{xx} , I_{yy} , I_{xy}) for the four different beam sections: I-, L-, C-, and Box. Fill in the following table, where the centroid is measured from the bottom-left corner of the beam, and the inertia properties are calculated about the centroid. Calculate ($EI_{xx}/\rho A$) for each section and comment which of the four beams provides the greatest bending stiffness per pound of weight (maximum $EI_{xx}/\rho A$). Explain.

	I-Section (A)	L-Section (B)	C-Section (C)	Box (D)
A (inch ²)				
ρA (lb/in)				
$X_{\rm c}$ (inch)				
Y _c (inch)				
I_{xx} (inch ⁴)				
I _{yy} (inch ⁴)				
I _{xy} (inch ⁴)				
$EI_{xx}/\rho A$				

Design Studies: NACA 4-Digit Airfoil

Using your MATLAB program and the four provided airfoil EXCEL files answer the following:

1.) Calculate the section properties for three different airfoil thicknesses; thin (NACA-0008), nominal (NACA-0014), and thick (NACA-0018). Also calculate the section properties for a highly cambered airfoil (NACA-4414). Calculate ($EI_{xx}/\rho A$) for each wing about the modulus-weighted centroid. Which airfoil provides the greatest wing bending stiffness per pound of wing weight?

	NACA-0008	NACA-0014	NACA-0018	NACA-4414
$EI_{xx}/\rho A$				

2.) Calculate the NACA-0014 section properties for regular skin and internal spar thickness, and compare to an airfoil with double skin and internal spar thickness. Fill in the following table with the wing bending stiffness (EI_{xx}) and wing bending stiffness per wing weight ($EI_{xx}/\rho A$) for each. Comment on the effectiveness of increasing the wing skin thickness in order to increase the wing bending stiffness (EI_{xx}). Is the added weight (ρA) worth it?

	NACA-0014 (Regular wall thickness)	NACA-0014 (Double wall thickness)
I_{xx}		
$EI_{xx}/\rho A$		

1 A	В	С	D	E	F	G	Н	I	J	К	L	MN
2			roject (#4) - Prope									
3	SE-160	A Aerospo	ace Structural Analysis, L	Iniversity of Califo	ornia, San Dieg	go (Copyright	J.B. Kosmatk	(a, 2020)				
5		Version:	Winter, 2020 (v1)									
6												
7	Pr	oject Title:	Test Case		1				I	à		
9		Variable	Di-ti	Malus.	11-2-			~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	U-it- D	eference		
10		ilnput	Description Input Units	Value 1	Units 1 = US, 2 = SI	***************************************			US	SI		
11		iOutput	Output Units	1	1 = US, 2 = SI			X	inch	ст		
12								Y	inch	ст		
13		Variable	Description	Value				t	inch	ст		
14		isection	Cross-Section Type	1	1 = General, 2	= NACA Airfoil		A	in ²	cm ²		
15		Хо	User defined origin	0				I_{xx} , I_{yy} , I_{xy}	in ⁴	cm ⁴		
16		Yo	User defined origin	0				ρ	lb/in ³	g/cm ³		
17								Е	$10^6 lb/in^2$	GPa		
18												
19	Х	Option 1:	General Thin Wall Cross-	-Section						1		
20	-	Mari-Li	Di	. V−1.	11!							
21 22	-	Variable #nodes	Description Number of nodes	Value 2	Units max of 20						-	
23			Number of Segments	2	max of 20 max of 20							
24				_								_
25		Node Defini	ition with Stringers (Conce									
26		(#)	X_i	Y_i	A	I_{xx}	I_{yy}	I_{xy}	ρ	E		
27		1									***********************	
28 29		2										_
30	-	3 4										
31		5										
32		6										
33		7										
34		8									****************	
35 36		9									**************************************	nonempenenter:
37		11										_
38		12										
39		13										
40		14										_
41 42		15 16										
43		17									************************	***********
44		18										***********
45		19										
46		20										
47 48		Segment Co										-
48		(#)	node (i)	node (j)	t	ρ	E					
50		1	noue (i)	noue (j)		Ρ	L					
51		2								s occasionados		
52		3										
53		4								-		
54 55		5 6								-		
56	-	7									ļ	
57		8						***************************************	<u> </u>	***************************************		anne penerane
58		9								S C C C C C C C C C C C C C C C C C C C		
59		10								-		
60		11										_
61 62		12 13								and a second		
63		13										
64		15									ļ	***********
65		16								***************************************	ļ	
66		17										\bot
67		18								announce .		

1	АВ	С	D	E	F	G	Н	ı	J	К	L MN
68	/ B	19	U	Ē.	F	U	П	<u>'</u>	J	K	L IVI IV
69		20									ļ
70	-	20									
71	+										
72	Х	Ontion 2	NACA 4-Digit Airfoil								ļ
73	^	Option 2:	NACA 4-DIGIT AIRTOII							}	-
74				M	P	TT					
75	_		4-Digit Definition Code:	IVI	Р	1.1					
76	-		4-Digit Definition Code:								
77	-	Airfail Outo	r Skin Geometry and Materio	d Definition							
78		Alijoli Gute	Description	Value	Units	***************************************					-
79	-	Heagmants	segments along chord	Value	Offics						
80	-	r-segments C	chord length								<u> </u>
81	-	t	wall thickness								ļ
82	-		density								
83	-	$\frac{\rho}{E}$	Young's modulus								
84	-	E	roung a moudius		<u> </u>						
85		Vertical Sno	r Geometry and Material De	finition (maximu	m of 5)						ļ
86	-	x/c	t deometry and Material De	ρ	E E					The state of the s	
87	-	λ/ ι	ı	ρ	L						
88	-										
89	-										
90	-										
91	-										
92	-										
93	-	Stringer pro	perty and Material Definitio	n (maximum of 2	(n)						
94	+	(#)	X _i	Y _i	A	I_{xx}	I_{yy}	Ixy	ρ	E	<u> </u>
95	-	1	21	- 1	А	* xx	2 yy	2 xy	P	L	
96	-	2									
97	-	3									
98	-	4									
99	-	5									
100		6									
101	-	7									
102	-	8									
103	-	9									·
104	-	10									<u> </u>
105	+	11									f
106	1	12									1
107	1	13									
108		14									·····
109		15									
110	1	16									1
111	1	17									<u> </u>
112	-	18									f
113	***************************************	19									
114	1	20									1
115	-										1
116		END OF F	LE							1	

A 1	В	С	D	E	F	G	Н	I	J	K	L ľ
	MA	TLAB P	roject (#1) - Prope	erties of Thin-	Wall Gene	ral Cross-	Sections				
3	SE-16	OA Aerospo	ce Structural Analysis, L	University of Califo	ornia, San Dieg	o (Copyright .	J.B. Kosmatk	a, 2020)			
5		Version:	Winter, 2020 (v1)								
6		VCISIOII.	vviii(ci, 2020 (vi)								
7	Stu	dent Name:				in the second					
8		Student ID:									
9								***************************************			
10	P	roject Title:									
11						ananana.					
	INPUT	ECHO:									
13						***************************************				_	
14		Variable	Description	Value	Units	TATAL DE LA CALLACATION DE LA			Units Re		
15 16		iInput iOutput	Input Units Output Units	1	1 = US, 2 = SI 1 = US, 2 = SI	and the same of th		X	US inch	SI	
17		ισαιραι	Output Offics	1	1 - 03, 2 - 31	and a second		Y	inch	cm cm	
18		Variable	Description	Value		ana ana		t	inch	cm	
19		isection	Cross-Section Type	1	1 = General, 2 =	= NACA Airfoil		A	in ²	cm ²	
20		Xo		0	- Scricial, Z	AT NOT AITIUI			in ⁴	cm ⁴	
_			User defined origin		1	and the second		I_{xx} , I_{yy} , I_{xy}	lb/in ³	g/cm ³	
21		Yo	User defined origin	0		200		ρ			
22								E	10 ⁶ lb/in ²	GPa	
23 24	v	Ontion 4:	Gonoral Thin Wall Crass	Section		anadata.					
25	Χ	Option 1:	General Thin Wall Cross	-Section		and a second					
26		Variable	Description	Value	Units	Anna Anna Anna Anna Anna Anna Anna Anna					
27			Number of nodes		max of 20	and the same of th					
28			Number of Segments		max of 20						
29											
30		Node Defini	tion with Stringers (Conce								
31		(#)	X_{i}	\boldsymbol{Y}_{i}	A	I_{xx}	I_{yy}	I_{xy}	ρ	E	
32		1									
33		2									
34		3									
35 36		<u>4</u> 5									
37		6									
38		7									
39		8									
40		9									
41		10									
42		11									
43		12									***************************************
44 45		13 14									***********************
46		15									
47		16									
48		17									
49		18									
50		19									
51		20									
52									***************************************	******************************	
53		Segment Co (#)		mada (*)	4		E				
- 4 1		(#)	node (i)	node (j)	t	ρ	E				
54											
55		1									
56		1 2									
55 56 57		1									
55 56 57 58 59		1 2 3									
55 56 57 58 59		1 2 3 4 5 6									
55 56 57 58 59 60 61		1 2 3 4 5 6 7									
54 55 56 57 58 59 60 61 62		1 2 3 4 5 6 7 8									
55 56 57 58 59 660 661 662 663		1 2 3 4 5 6 7 8									
55 55 55 55 55 55 55 55		1 2 3 4 5 6 7 8									

1	4	В	С	D	E	F	G	Н	I	J	K	L	ΜN
67			13										
68			14										
69			15										
70			16								ana		
71			17							# # # # # # # # # # # # # # # # # # #			
72			18								200		
73			19										
73 74 75	-		20										
75	-								ļ				
76											name		
77 78	O	UTPL	JI:					a.	1		***		
79	1	1 \	Castian Dra	perties about Original Axes							anno		
80	1	1.)	Section Prop	berties about Original Axes				Name of the latest and the latest an	1		***************************************		
81	+		Area Proper	tios				Mass Propert	ies (Mass-Wei	ahted)	000		
82	-		Variable	Description	Value	Units		Variable	Description	Value	Units		
83	-			Area	value	inch ²	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	ρA	Weight	Value	lb/inch		~~~
	-												
84				Centroid		inch		X_{cg}	CG		inch		
85			\boldsymbol{Y}_{c}	Centroid		inch		Y_{cg}	CG		inch	***************************************	
86			I_{xx}	Inertia about x		inch ⁴		ρI_{xx}	Mass Inertia a	about x	lb-inch		
87	T			Inertia about y		inch ⁴		ρI_{yy}	Mass Inertia a	about v	lb-inch		
88	-			Product of Inertia		inch ⁴		ρI_{xy}	Mass Product		lb-inch		
89	+		⁴ xy	Judec of filer tid				P xy		J. mertia	io inch	-	
90			Stiffness Dra	pperties (Modulus-Weighted,)		******************************						
91	+-		Variable	Description	/ Value	Units	***************************************		***************************************		0		***************************************
92	-			Axial Stiffness	value	inch ²							
93	-					inch					1000		
	-			Mod weighted centroid							and		
94	-			Mod weighted centroid		inch							
95			EI_{xx}	Inertia about x		inch ⁴		A. O. C.					
96			EI_{yy}	Inertia about y		inch ⁴					000		
97				Product of Inertia		inch ⁴					0.00		
98	-		xy										
99	+							1			No.		
100			Plot of Cros	ss-Section in Initial Coordinat	e Svstem								
101					,								
102													
103	1												
104													
105													
106													
107													
109													
110													
111													
112													
108 109 110 111 112 113 114 115													
114													
115	-												
116													
117	-	_											
118	-												
119	-												
121	-												
122	-	\dashv											
122	+												
124	-												
125	+												
126	-	\dashv											
127		\dashv											
128	+												
129	1												
116 117 118 119 120 121 122 123 124 125 126 127 128 129 130	1												- Constant
131		2.)	Section Pro	perties about Centroidal Axe	s (origin is placed	at area centroid	l)						-
		•			-								

A	В	С	D	Е	F	G	Н	I	J	K	L	ΜN
132					~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~		A4 D	hi (MA W-i			****	
133 134		Area Prope	Description	Value	Units		Variable	Description	Value	Units		
135		A	Area	value	inch ²		ρA	Weight	value	lb/inch		
136		X_c	Centroid		inch	***************************************	X_{cg}	CG		inch		
137		Y_c	Centroid		inch		Y_{cg}	CG		inch		_
138			Inertia about x		inch ⁴			Mass Inertia a	hout v	lb-inch		
-		Ixx			inch ⁴		ρI_{xx}					
139		I yy	Inertia about y				ρI_{yy}	Mass Inertia a	· ·	lb-inch		
140		I xy	Product of Inertia		inch ⁴		ρI_{xy}	Mass Product	of Inertia	lb-inch	4	
141 142		Stiffnoss Dr	 operties (Modulus-Weighted	<u> </u>	-				******************************			
143		Variable	Description	Value	Units							
144		EA	Axial Stiffness		inch ²							
145	-	-	Mod weighted centroid		inch				***************************************			annon pananono
146		-	Mod weighted centroid		inch							
147		EI_{xx}	Inertia about x		inch ⁴					000	+	_
148	-	EI_{yy}	Inertia about y		inch ⁴	***************************************						***********
-			-		inch ⁴					0000		
149 150	-	EI xy	Product of Inertia		IIICII				, , , , , , , , , , , , , , , , , , ,	***************************************		
151	3.) Section Pro	perties about Modulus-Weig	hted Centroid (or	igin is placed a	t modulus weis	 phted centroic	1)		anne.		
152		, 5550.5			lg is piacea a					70000000		
153		Area Prope	rties				Mass Propert	ties (Mass-Weig	ghted)			
154		Variable	Description	Value	Units		Variable	Description	Value	Units		
155		A	Area		inch ²		ρA	Weight		lb/inch		
156		X_c	Centroid		inch		X_{cg}	CG		inch		
157		Y_c	Centroid		inch		Y_{cg}	CG		inch		
158		I_{xx}	Inertia about x		inch ⁴		ρI_{xx}	Mass Inertia a	bout x	lb-inch		
159		I_{yy}	Inertia about y		inch ⁴		ρI_{yy}	Mass Inertia a	bout y	lb-inch		
160		I_{xy}	Product of Inertia		inch ⁴		ρI_{xy}	Mass Product	of Inertia	lb-inch		
161												.nonen-beneau
162			operties (Modulus-Weighted							on annual of		
163		Variable	Description	Value	Units							
164			Axial Stiffness		inch ²							
165			Mod weighted centroid		inch					2		
166			Mod weighted centroid		inch							
167		EI_{xx}	Inertia about x		inch ⁴				******************************			
168		EI_{yy}	Inertia about y		inch ⁴							
169		EI_{xy}	Product of Inertia		inch ⁴					000000000000000000000000000000000000000		
170												
171	4.) Section Pro	perties about User-Defined	Origin				1		***************************************		
172 173		Area Prope	rtioc				Maca Drama	ties (Mass-Wei	ahtad)	and a second		
174		Variable	Description	Value	Units		Variable	Description	Value	Units	-	
175		A	Area	74.40	inch ²		ρA	Weight	Falac	lb/inch		
176			Centroid		inch		X_{cg}	CG		inch	1	
177	1	Y_c	Centroid		inch	_	Y_{cg}	CG		inch		
178			Inertia about x		inch ⁴			Mass Inertia a	hout v	lb-inch	1	
179		I	Inertia about x		inch ⁴		ρI_{xx}	1		lb-inch	 	
		I yy	•		inch ⁴		ρI_{yy}	Mass Inertia a	· ·		H	
180 181		I _{xy}	Product of Inertia		IIICII		ρI_{xy}	Mass Product	or inertia	lb-inch	4	_
182	-	Stiffness Pro	 operties (Modulus-Weighted	L								
183		Variable	Description	Value	Units					- va		
184			Axial Stiffness		inch ²					5		
185			Mod weighted centroid		inch						1	
186			Mod weighted centroid		inch							
187		EI_{xx}	Inertia about x		inch ⁴	***************************************			***************************************			*****
188		EI yy	Inertia about y		inch ⁴					and	-	
189	-		Product of Inertia		inch ⁴	***************************************			<u></u>			
190		EI_{xy}	r rounce of filered		men					0.000		
190	End o	of Output										

А	В	С	D	E	F	G	Н	1	J	K	L MN
1											
2			roject (#4) - Propert						ıs		
3	SE-16		ce Structural Analysis, Un	iversity of Califor	rnia, San Diego	(Copyright	J.B. Kosmatka	, 2020)			
5		Version:	Winter, 2020 (v1)								
7	CALL	dent Name:									
8		Student ID:									
9											
10	P	roject Title:					,				
11 12	INDIT	ECHO:									
13		LCHO.									
14		Variable	Description	Value	Units				Units Re	ference	
15		iInput	Input Units	1	1 = US, 2 = SI			V	US	SI	
16 17		iOutput	Output Units	1	1 = US, 2 = SI			X Y	inch inch	cm cm	
18		Variable	Description	Value				t	inch	ст	
19		isection	Cross-Section Type	1	1 = General, 2	= NACA Airfoil		A	in ²	cm ²	
20		Хо	User defined origin	0				I_{xx} , I_{yy} , I_{xy}	in ⁴	cm ⁴	
21		Yo	User defined origin	0				ρ	lb/in ³	g/cm ³	
22								E	$10^6 lb/in^2$	GPa	
23	Х	Ontion 3	NACA 4-Digit Airfoil								
25	^	Option 2:	NACA 4-DIGIT AIRIOII								
26				M	Р	TT					
27		-	4-Digit Definition Code:					-		-	
28 29		Airfoil Oute	r Skin Geometry and Materio	al Definition							
30		All Joli Oute	Description Description	Value	Units						
31		#segments	segments along chord								
32		С	chord length								
33 34		ρ	wall thickness density								
35		E	Young's modulus								
36											
37 38		vertical Spa x/c	r Geometry and Material De t	finition (maximum ρ	1 of 5) E						
39		K/ C	•	P	L						
40											
41											
43											
44											
45		Stringer pro	perty and Material Definition	n (maximum of 20		7	7	7		-	
46 47		(#) 1	X_i	I i	A	Ixx	I_{yy}	I_{xy}	ρ	E	
48		2									
49		3									
50 51		<u>4</u> 5									
52		6									
53		7									
54 55		8 9									
56		10									
57		11									
58 59		12 13									<u> </u>
60		13									
61		15									
62		16									
63 64		17 18									
65		19									
66		20									
67 68											
69	OUTP	UT:									
70											
71	1.)	Section Pro	perties about Leading Edge								
72											

Δ	В	С	D	E	F	G	H	1	J	K	L M
73		Area Prope						ies (Mass-Weig		K	
74		Variable	Description	Value	Units		Variable	Description	Value	Units	1
75		A	Area		inch ²		ρA	Weight		lb/inch	
76		X_c	Centroid		inch		X_{cg}	CG		inch	
77		Y_c	Centroid		inch		Y_{cg}	CG		inch	
78		I_{xx}	Inertia about x		inch ⁴		ρI_{xx}	Mass Inertia a	hout v	lb-inch	
79					inch ⁴					lb-inch	
\vdash		Iyy	Inertia about y		inch⁴		ρI_{yy}	Mass Inertia a			
80		I_{xy}	Product of Inertia		incn		ρI_{xy}	Mass Product	of Inertia	lb-inch	
81		C4:ff D	 operties (Modulus-Weighted	1							<u> </u>
82 83		Variable	Description	/ Value	Units						
84		EA	Axial Stiffness	Value	inch ²						
85		X_{EA}	Mod weighted centroid		inch						
\vdash			_								
86		Y_{EA}	Mod weighted centroid		inch						<u> </u>
87		EI_{xx}	Inertia about x		inch ⁴						
88		EI_{yy}	Inertia about y		inch ⁴						
89		EI_{xy}	Product of Inertia		inch ⁴						
90											
91											
92		Plot of the	NACA 4-Digit Airfoil Cross-Se	ction in Initial Coo	rdinate System						
93											
94 95											
96											
97											
98											<u> </u>
99											
100											
101											
102											<u> </u>
103											
104											
-				l			ı			1	
105	21	Saction Dra	portios about Controidal Ava	os (arigin is placed	at area centrois	11					
105 106	2.)	Section Pro	perties about Centroidal Axe	es (origin is placed	at area centroic	1)					
105 106 107	2.)			es (origin is placed	at area centroid	1)	Mass Propert	ies (Mass-Weid	nhted)		
105 106	2.)	Section Pro		es (origin is placed	at area centroid	(K	Mass Propert	ies (Mass-Weig Description	ghted) Value	Units	
105 106 107 108	2.)	Area Prope	rties			1)	-		-	Units Ib/inch	
105 106 107 108 109	2.)	Area Proper Variable	rties Description		Units	1)	Variable ρA	Description	-		
105 106 107 108 109 110	2.)	Area Proper Variable A X _c	Description Area Centroid		Units inch ²	1)	Variable ρA X_{cg}	Description Weight CG	-	lb/inch inch	
105 106 107 108 109 110 111 112	2.)	Area Proper Variable A X C Y C	rties Description Area Centroid Centroid		Units inch² inch	3)	$\begin{array}{c} \textbf{Variable} \\ \rho A \\ X_{cg} \\ Y_{cg} \end{array}$	Description Weight CG CG	Value	lb/inch inch inch	
105 106 107 108 109 110 111 112 113	2.)	Area Proper Variable A X C Y C I xx	rties Description Area Centroid Centroid Inertia about x		Units inch² inch inch	4)	$\begin{array}{c} \textbf{Variable} \\ \rho A \\ X_{cg} \\ Y_{cg} \\ \rho I_{xx} \end{array}$	Description Weight CG CG Mass Inertia a	Value bout x	lb/inch inch inch lb-inch	
105 106 107 108 109 110 111 112 113 114	2.)	Area Propei Variable A X _c Y _c I _{xx} I _{yy}	rties Description Area Centroid Centroid Inertia about x Inertia about y		Units inch² inch inch inch4	4)	$\begin{array}{c} \textbf{Variable} \\ \hline \rho A \\ X_{cg} \\ Y_{cg} \\ \hline \rho I_{xx} \\ \hline \rho I_{yy} \\ \end{array}$	Description Weight CG CG Mass Inertia a Mass Inertia a	Value bout x bout y	Ib/inch inch inch Ib-inch	
105 106 107 108 109 110 111 112 113 114	2.)	Area Proper Variable A X C Y C I xx	rties Description Area Centroid Centroid Inertia about x		Units inch² inch inch	4)	$\begin{array}{c} \textbf{Variable} \\ \rho A \\ X_{cg} \\ Y_{cg} \\ \rho I_{xx} \end{array}$	Description Weight CG CG Mass Inertia a	Value bout x bout y	lb/inch inch inch lb-inch	
105 106 107 108 109 110 111 112 113 114 115	2.)	Area Propes Variable A X _c Y _c I _{xx} I _{yy} I _{xy}	rties Description Area Centroid Centroid Inertia about x Inertia about y Product of Inertia	Value	Units inch² inch inch inch4	2)	$\begin{array}{c} \textbf{Variable} \\ \hline \rho A \\ X_{cg} \\ Y_{cg} \\ \hline \rho I_{xx} \\ \hline \rho I_{yy} \\ \end{array}$	Description Weight CG CG Mass Inertia a Mass Inertia a	Value bout x bout y	Ib/inch inch inch Ib-inch	
105 106 107 108 109 110 111 112 113 114 115 116 117	2.)	Area Proper Variable A X _c Y _c I _{xx} I _{yy} I _{xy} Stiffness Pro	Description Area Centroid Centroid Inertia about x Inertia about y Product of Inertia	Value	Units inch² inch inch inch⁴ inch⁴	2)	$\begin{array}{c} \textbf{Variable} \\ \hline \rho A \\ X_{cg} \\ Y_{cg} \\ \hline \rho I_{xx} \\ \hline \rho I_{yy} \\ \end{array}$	Description Weight CG CG Mass Inertia a Mass Inertia a	Value bout x bout y	Ib/inch inch inch Ib-inch	
105 106 107 108 109 110 111 112 113 114 115 116 117	2.)	Area Proper Variable A X _c Y _c I _{xx} I _{yy} I _{xy} Stiffness Provided the second secon	Tiles Description Area Centroid Centroid Inertia about x Inertia about y Product of Inertia Description	Value	Units inch² inch inch inch inch ⁴ inch ⁴	3)	$\begin{array}{c} \textbf{Variable} \\ \hline \rho A \\ X_{cg} \\ Y_{cg} \\ \hline \rho I_{xx} \\ \hline \rho I_{yy} \\ \end{array}$	Description Weight CG CG Mass Inertia a Mass Inertia a	Value bout x bout y	Ib/inch inch inch Ib-inch	
105 106 107 108 109 110 111 112 113 114 115 116 117 118	2.)	$Area \ Proper \\ Variable \\ A \\ X_c \\ Y_c \\ I_{xx} \\ I_{yy} \\ I_{xy} \\ Stiffness \ Pro \\ Variable \\ EA$	Titles Description Area Centroid Centroid Inertia about x Inertia about y Product of Inertia Description Axial Stiffness	Value	Units inch² inch inch4 inch4 inch4 inch5 inch64 inch64		$\begin{array}{c} \textbf{Variable} \\ \hline \rho A \\ X_{cg} \\ Y_{cg} \\ \hline \rho I_{xx} \\ \hline \rho I_{yy} \\ \end{array}$	Description Weight CG CG Mass Inertia a Mass Inertia a	Value bout x bout y	Ib/inch inch inch Ib-inch	
105 106 107 108 109 110 111 112 113 114 115 116 117 118 119	2.)		rties Description Area Centroid Centroid Inertia about x Inertia about y Product of Inertia perties (Modulus-Weighted Description Axial Stiffness Mod weighted centroid	Value	Units inch² inch inch inch4 inch4 inch4 inch4 inch4		$\begin{array}{c} \textbf{Variable} \\ \hline \rho A \\ X_{cg} \\ Y_{cg} \\ \hline \rho I_{xx} \\ \hline \rho I_{yy} \\ \end{array}$	Description Weight CG CG Mass Inertia a Mass Inertia a	Value bout x bout y	Ib/inch inch inch Ib-inch	
105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120	2.)	Area Proper Variable A X _c Y _c I _{xx} I _{yy} I _{xy} Stiffness Proving EA X _{EA} Y _{EA}	Area Centroid Centroid Inertia about x Inertia about y Product of Inertia Description Axial Stiffness Mod weighted centroid Mod weighted centroid	Value	Units inch² inch inch4 inch4 inch4 inch5 inch6 i		$\begin{array}{c} \textbf{Variable} \\ \hline \rho A \\ X_{cg} \\ Y_{cg} \\ \hline \rho I_{xx} \\ \hline \rho I_{yy} \\ \end{array}$	Description Weight CG CG Mass Inertia a Mass Inertia a	Value bout x bout y	Ib/inch inch inch Ib-inch	
105 106 107 108 109 110 111 112 113 114 115 116 117 118 119	2.)		rties Description Area Centroid Centroid Inertia about x Inertia about y Product of Inertia perties (Modulus-Weighted Description Axial Stiffness Mod weighted centroid	Value	Units inch² inch inch4 inch4 inch4 inch5 inch2 inch2 inch inch inch		$\begin{array}{c} \textbf{Variable} \\ \hline \rho A \\ X_{cg} \\ Y_{cg} \\ \hline \rho I_{xx} \\ \hline \rho I_{yy} \\ \end{array}$	Description Weight CG CG Mass Inertia a Mass Inertia a	Value bout x bout y	Ib/inch inch inch Ib-inch	
105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120	2.)	Area Proper Variable A X _c Y _c I _{xx} I _{yy} I _{xy} Stiffness Proving EA X _{EA} Y _{EA}	Area Centroid Centroid Inertia about x Inertia about y Product of Inertia Description Axial Stiffness Mod weighted centroid Mod weighted centroid	Value	Units inch² inch inch inch4 inch4 inch4 inch4 inch4 inch4 inch4 inch inch inch inch inch inch inch		$\begin{array}{c} \textbf{Variable} \\ \hline \rho A \\ X_{cg} \\ Y_{cg} \\ \hline \rho I_{xx} \\ \hline \rho I_{yy} \end{array}$	Description Weight CG CG Mass Inertia a Mass Inertia a	Value bout x bout y	Ib/inch inch inch Ib-inch	
105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121	2.)		Titles Description Area Centroid Centroid Inertia about x Inertia about y Product of Inertia Description Axial Stiffness Mod weighted centroid Mod weighted centroid Inertia about x	Value	Units inch² inch inch4 inch4 inch4 inch5 inch2 inch2 inch inch inch		$\begin{array}{c} \textbf{Variable} \\ \hline \rho A \\ X_{cg} \\ Y_{cg} \\ \hline \rho I_{xx} \\ \hline \rho I_{yy} \end{array}$	Description Weight CG CG Mass Inertia a Mass Inertia a	Value bout x bout y	Ib/inch inch inch Ib-inch	
105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123	2.)	$Area Proper Variable A X_c Y_c I_{xx} I_{yy} I_{xy} Stiffness Proving E A X_EA Y_EA E I_{xx} E I_{yy}$	Titles Description Area Centroid Centroid Inertia about x Inertia about y Product of Inertia Description Axial Stiffness Mod weighted centroid Mod weighted centroid Inertia about x Inertia about y	Value	Units inch² inch inch inch4 inch4 inch4 inch4 inch4 inch4 inch4 inch inch inch inch inch inch inch		$\begin{array}{c} \textbf{Variable} \\ \hline \rho A \\ X_{cg} \\ Y_{cg} \\ \hline \rho I_{xx} \\ \hline \rho I_{yy} \end{array}$	Description Weight CG CG Mass Inertia a Mass Inertia a	Value bout x bout y	Ib/inch inch inch Ib-inch	
105 106 107 108 109 110 1111 1112 113 114 115 116 117 118 119 120 121 122 123 124 125 126		$Area Proper Variable \\ A \\ X_c \\ Y_c \\ I_{xx} \\ I_{yy} \\ I_{xy} \\ Stiffness Prove Variable \\ EA \\ X_{EA} \\ Y_{EA} \\ EI_{xx} \\ EI_{xx} \\ EI_{xy} \\ EI_{xy} \\$	Titles Description Area Centroid Centroid Inertia about x Inertia about y Product of Inertia Description Axial Stiffness Mod weighted centroid Mod weighted centroid Inertia about x Inertia about y	Value Value Value	Units inch² inch inch inch4 inch4 inch4 inch4 inch4 inch4 inch inch inch inch inch inch inch inch		$ \begin{array}{c} \textbf{Variable} \\ \rho A \\ X_{cg} \\ Y_{cg} \\ \rho I_{xx} \\ \rho I_{yy} \\ \rho I_{xy} \end{array} $	Description Weight CG CG Mass Inertia a Mass Product	Value bout x bout y	Ib/inch inch inch Ib-inch	
105 106 107 108 109 1110 1111 1122 1133 1144 1155 1166 117 1188 1199 1200 1211 1222 1233 1244 1255 1266 127			Titles Description Area Centroid Centroid Inertia about x Inertia about y Product of Inertia Description Axial Stiffness Mod weighted centroid Inertia about x Inertia about y Product of Inertia	Value Value Value	Units inch² inch inch inch4 inch4 inch4 inch4 inch4 inch4 inch inch inch inch inch inch inch inch		$\begin{array}{c} \textbf{Variable} \\ \rho A \\ X_{cg} \\ Y_{cg} \\ \rho I_{xx} \\ \rho I_{yy} \\ \rho I_{xy} \end{array}$	Description Weight CG CG Mass Inertia a Mass Product	Value bout x bout y of Inertia	Ib/inch inch inch Ib-inch	
105 106 107 108 109 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128			Description Area Centroid Centroid Inertia about x Inertia about y Product of Inertia Description Axial Stiffness Mod weighted centroid Inertia about x Inertia about y Product of Inertia Description Axial Stiffness Mod weighted centroid Inertia about y Product of Inertia Description Inertia about y Product of Inertia	Value Value Value thted Centroid (or	Units inch² inch inch4 inch4 inch4 inch5 inch6 inch1 inch1 inch1 inch1 inch6 i		$\begin{array}{c} \text{Variable} \\ \rho A \\ X_{cg} \\ Y_{cg} \\ \rho I_{xx} \\ \rho I_{yy} \\ \rho I_{xy} \end{array}$	Description Weight CG CG Mass Inertia a Mass Product	value bout x bout y of Inertia	lb/inch inch inch lb-inch lb-inch	
105 106 107 108 109 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 120			Description Area Centroid Centroid Inertia about x Inertia about y Product of Inertia Description Axial Stiffness Mod weighted centroid Inertia about x Inertia about y Product of Inertia Description Axial Stiffness Mod weighted centroid Inertia about y Product of Inertia Description Inertia about y Product of Inertia Description	Value Value Value	Units inch² inch inch inch4 inch4 inch4 inchb² inchb² inch inch inch inch inch inch inch inch		$\begin{array}{c} \text{Variable} \\ \rho A \\ X_{cg} \\ Y_{cg} \\ \rho I_{xx} \\ \rho I_{yy} \\ \rho I_{xy} \end{array}$	Description Weight CG CG Mass Inertia a Mass Product Mass Product ies (Mass-Weig Description	Value bout x bout y of Inertia	Ib/inch inch inch Ib-inch Ib-inch Ib-inch Units	
105 106 107 108 109 1110 1111 1122 1133 1144 1155 1166 117 118 119 120 121 122 123 124 125 126 127 128 129 130			Description Area Centroid Centroid Inertia about x Inertia about y Product of Inertia Description Axial Stiffness Mod weighted centroid Inertia about x Inertia about y Product of Inertia Description Axial Stiffness Mod weighted centroid Inertia about y Product of Inertia Description Area	Value Value Value thted Centroid (or	Units inch² inch inch4 inch4 inch4 inch5 inch6 inch6 inch6 inch1 inch6 i		$\begin{array}{c} \text{Variable} \\ \rho A \\ X_{cg} \\ Y_{cg} \\ \rho I_{xx} \\ \rho I_{yy} \\ \rho I_{xy} \\ \end{array}$	Description Weight CG CG Mass Inertia a Mass Product Mass Product Mass Product Mass Product Mass Product Mass Product	value bout x bout y of Inertia	Ib/inch inch inch Ib-inch Ib-inch Ib-inch Units Ib/inch	
105 106 107 108 109 1110 1111 1112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 131			Titles Description Area Centroid Centroid Inertia about x Inertia about y Product of Inertia Description Axial Stiffness Mod weighted centroid Inertia about x Inertia about y Product of Inertia Description Axial Stiffness Mod weighted centroid Inertia about y Product of Inertia Description Area Centroid	Value Value Value thted Centroid (or	Units inch² inch inch4 inch4 inchb² inchb² inchb² inch inchbinch inchbinch inchbinchbinchbinchbinchbinchbinchbinchb		$\begin{array}{c} \textbf{Variable} \\ \rho A \\ X_{cg} \\ Y_{cg} \\ \rho I_{xx} \\ \rho I_{yy} \\ \rho I_{xy} \\ \end{array}$	Description Weight CG CG Mass Inertia a Mass Product Mass Product ies (Mass-Weig Description Weight CG	value bout x bout y of Inertia	Ib/inch inch inch Ib-inch Ib-inch Ib-inch Ib-inch Ib-inch Ib-inch	
105 106 107 108 109 1110 1111 1122 1133 1144 1155 1166 117 118 119 120 121 122 123 124 125 126 127 128 129 130			Description Area Centroid Centroid Inertia about x Inertia about y Product of Inertia Description Axial Stiffness Mod weighted centroid Inertia about x Inertia about y Product of Inertia Description Axial Stiffness Mod weighted centroid Inertia about y Product of Inertia Description Area	Value Value Value thted Centroid (or	Units inch² inch inch4 inch4 inch4 inchb² inchb² inch inchb² inch inchbinch inchbinch inchbinchbinchbinchbinchbinchbinchbinchb		$\begin{array}{c} \text{Variable} \\ \rho A \\ X_{cg} \\ Y_{cg} \\ \rho I_{xx} \\ \rho I_{yy} \\ \rho I_{xy} \\ \end{array}$	Description Weight CG CG Mass Inertia a Mass Product Mass Product Mass Product Mass Product Mass Product Mass Product	value bout x bout y of Inertia	Ib/inch inch inch Ib-inch Ib-inch Ib-inch Units Ib/inch	
105 106 107 108 109 1110 1111 1112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 131			Titles Description Area Centroid Centroid Inertia about x Inertia about y Product of Inertia Description Axial Stiffness Mod weighted centroid Inertia about x Inertia about y Product of Inertia Description Axial Stiffness Mod weighted centroid Inertia about y Product of Inertia Description Area Centroid	Value Value Value thted Centroid (or	Units inch² inch inch4 inch4 inchb² inchb² inchb² inch inchbinch inchbinch inchbinchbinchbinchbinchbinchbinchbinchb		$\begin{array}{c} \textbf{Variable} \\ \rho A \\ X_{cg} \\ Y_{cg} \\ \rho I_{xx} \\ \rho I_{yy} \\ \rho I_{xy} \\ \end{array}$	Description Weight CG CG Mass Inertia a Mass Product Mass Product ies (Mass-Weig Description Weight CG	bout x bout y of Inertia	Ib/inch inch inch Ib-inch Ib-inch Ib-inch Ib-inch Ib-inch Ib-inch	
105 106 107 108 109 1110 1111 1112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 131 131 131 142 133 144 155 166 177 188 199 199 199 199 199 199 199			Titles Description Area Centroid Centroid Inertia about x Inertia about y Product of Inertia Description Axial Stiffness Mod weighted centroid Inertia about x Inertia about y Product of Inertia Description Axial Stiffness Mod weighted centroid Inertia about x Inertia about y Product of Inertia Description Area Centroid Centroid	Value Value Value thted Centroid (or	Units inch² inch inch4 inch4 inch4 inchb² inchb² inch inchb² inch inchbinch inchbinch inchbinchbinchbinchbinchbinchbinchbinchb		$\begin{array}{c} \textbf{Variable} \\ \rho A \\ X_{cg} \\ Y_{cg} \\ \rho I_{xx} \\ \rho I_{yy} \\ \rho I_{xy} \\ \end{array}$	Description Weight CG CG Mass Inertia a Mass Product Mass	bout x bout y of Inertia	Ib/inch inch inch Ib-inch Ib-inch Ib-inch Ib-inch Ib-inch Ib-inch Ib-inch	
105 106 107 108 109 110 1111 1112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134			Tiles Description Area Centroid Centroid Inertia about x Inertia about y Product of Inertia Description Axial Stiffness Mod weighted centroid Inertia about x Inertia about y Product of Inertia Description Axial Stiffness Mod weighted centroid Inertia about x Inertia about y Product of Inertia Description Area Centroid Centroid Inertia about x	Value Value Value thted Centroid (or	Units inch² inch inch⁴ inch⁴ inch² inch⁴ inch⁴ inch² inch inch inch inch inch inch inch inch		$\begin{array}{c} \text{Variable} \\ \rho A \\ X_{cg} \\ Y_{cg} \\ \rho I_{xx} \\ \rho I_{yy} \\ \rho I_{xy} \\ \end{array}$	Description Weight CG CG Mass Inertia a Mass Product Mass Inertia a	bout x bout y of Inertia whted) Value bout x bout y	Units Ib/inch inch Ib-inch Ib-inch Ib-inch Ib-inch Ib-inch Ib-inch	
105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135			Titles Description Area Centroid Centroid Inertia about x Inertia about y Product of Inertia Description Axial Stiffness Mod weighted centroid Inertia about x Inertia about y Product of Inertia Description Axial Stiffness Mod weighted centroid Inertia about x Inertia about y Product of Inertia Description Area Centroid Centroid Inertia about x Inertia about y Inertia about Modulus-Weighted Centroid Centroid Inertia about y Inertia about y	Value Value Value thted Centroid (or	Units inch² inch inch⁴ inch⁴ inch¹ inch¹ inch¹ inch inch inch inch inch inch inch inch		$\begin{tabular}{c c} \textbf{Variable} \\ \hline ρA \\ X_{cg} \\ \hline ρI_{xx} \\ \hline ρI_{yy} \\ \hline ρI_{xy} \\ \hline ρI_{xy} \\ \hline \hline ρI_{xy} \\ \hline \hline ρI_{xy} \\ \hline ρI_{xx} \\ \hline \end{tabular}$	Description Weight CG CG Mass Inertia a Mass Product Mass Inertia a Mass Inertia a Mass Inertia a	bout x bout y of Inertia whted) Value bout x bout y	Units Ib/inch inch Ib-inch Ib-inch Ib-inch Ib-inch Ib-inch Ib-inch Ib-inch Ib-inch	
105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 130 131 135 136 136 136 130 131 135 136 136 130 131 135 136 136 130 131 135 136 136 130 131 135 136 136 130 130 130 131 135 136 136 130		Area Proper Variable A X _c Y _c I _{xx} I _{yy} I _{xy} Stiffness Pro Variable EA X _{EA} Y _{EA} EI _{xx} EI _{yy} EI _{xy} Section Pro Area Proper Variable A X _c Y _c I _{xx} I _{yy} I _{xy}	Titles Description Area Centroid Centroid Inertia about x Inertia about y Product of Inertia Description Axial Stiffness Mod weighted centroid Inertia about x Inertia about y Product of Inertia Description Axial Stiffness Mod weighted centroid Inertia about y Product of Inertia Description Area Centroid Centroid Inertia about x Inertia about y Product of Inertia	Value Value Value Value Value	Units inch² inch inch⁴ inch⁴ inch¹ inch¹ inch¹ inch inch inch inch inch inch inch inch		$\begin{array}{c} \text{Variable} \\ \rho A \\ X_{cg} \\ Y_{cg} \\ \rho I_{xx} \\ \rho I_{yy} \\ \rho I_{xy} \\ \end{array}$	Description Weight CG CG Mass Inertia a Mass Product Mass Inertia a Mass Inertia a Mass Inertia a	bout x bout y of Inertia whted) Value bout x bout y	Units Ib/inch inch Ib-inch Ib-inch Ib-inch Ib-inch Ib-inch Ib-inch Ib-inch Ib-inch	
105 106 107 108 109 1110 1111 1112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 130 131 132 133 134 135		Area Proper Variable A X _c Y _c I _{xx} I _{yy} I _{xy} Stiffness Pro Variable EA X _{EA} Y _{EA} EI _{xx} EI _{yy} EI _{xy} Section Pro Area Proper Variable A X _c Y _c I _{xx} I _{yy} I _{xy}	Titles Description Area Centroid Centroid Inertia about x Inertia about y Product of Inertia Description Axial Stiffness Mod weighted centroid Inertia about x Inertia about y Product of Inertia Description Axial Stiffness Mod weighted centroid Inertia about x Inertia about y Product of Inertia Description Area Centroid Centroid Inertia about x Inertia about y Inertia about Modulus-Weighted Centroid Centroid Inertia about y Inertia about y	Value Value Value Value Value	Units inch² inch inch⁴ inch⁴ inch¹ inch¹ inch¹ inch inch inch inch inch inch inch inch		$\begin{array}{c} \text{Variable} \\ \rho A \\ X_{cg} \\ Y_{cg} \\ \rho I_{xx} \\ \rho I_{yy} \\ \rho I_{xy} \\ \end{array}$	Description Weight CG CG Mass Inertia a Mass Product Mass Inertia a Mass Inertia a Mass Inertia a	bout x bout y of Inertia whted) Value bout x bout y	Units Ib/inch inch Ib-inch Ib-inch Ib-inch Ib-inch Ib-inch Ib-inch Ib-inch Ib-inch	

Α	В	С	D	E	F	G	Н	I	J	K	L	ΜN
139		EA	Axial Stiffness		inch ²							
140		X_{EA}	Mod weighted centroid		inch							
141		Y_{EA}	Mod weighted centroid		inch							
142		EI_{xx}	Inertia about x		inch ⁴							
143		EI_{yy}	Inertia about y		inch ⁴							
144		EI_{xy}	Product of Inertia		inch ⁴							
145												
146	4.)	Section Pro	perties about User-Defined	Origin	1	1	1	ı			1	
147		A D	**				14 D	i /84 14/-i-	-64-41			
148 149		Area Prope	Description Description	Value	Units		Variable	Description	Value	Units		+
150		A	Area	Value	inch ²		ρA	Weight	Value	lb/inch		
151		X_c	Centroid		inch		X_{cg}	CG		inch		
152		Y_c	Centroid		inch		Y _{cg}	CG		inch		
153		I_{xx}	Inertia about x		inch ⁴		ρI_{xx}	Mass Inertia a	bout x	lb-inch		
154		I_{vv}	Inertia about y		inch ⁴		ρI_{vv}	Mass Inertia a	bout y	lb-inch		
155		I_{xv}	Product of Inertia		inch ⁴		ρI_{xv}	Mass Product	of Inertia	lb-inch		
156												
157		Stiffness Pro	perties (Modulus-Weighted)								
158		Variable	Description	Value	Units							
159		EA	Axial Stiffness		inch ²							
160		X_{EA}	Mod weighted centroid		inch							
161		Y_{EA}	Mod weighted centroid		inch							
162		EI_{xx}	Inertia about x		inch ⁴							
163		EI_{yy}	Inertia about y		inch ⁴							
164		EI_{xy}	Product of Inertia		inch ⁴							
165												
166	End o	f Output										