Tutorial—Five Quick Problems

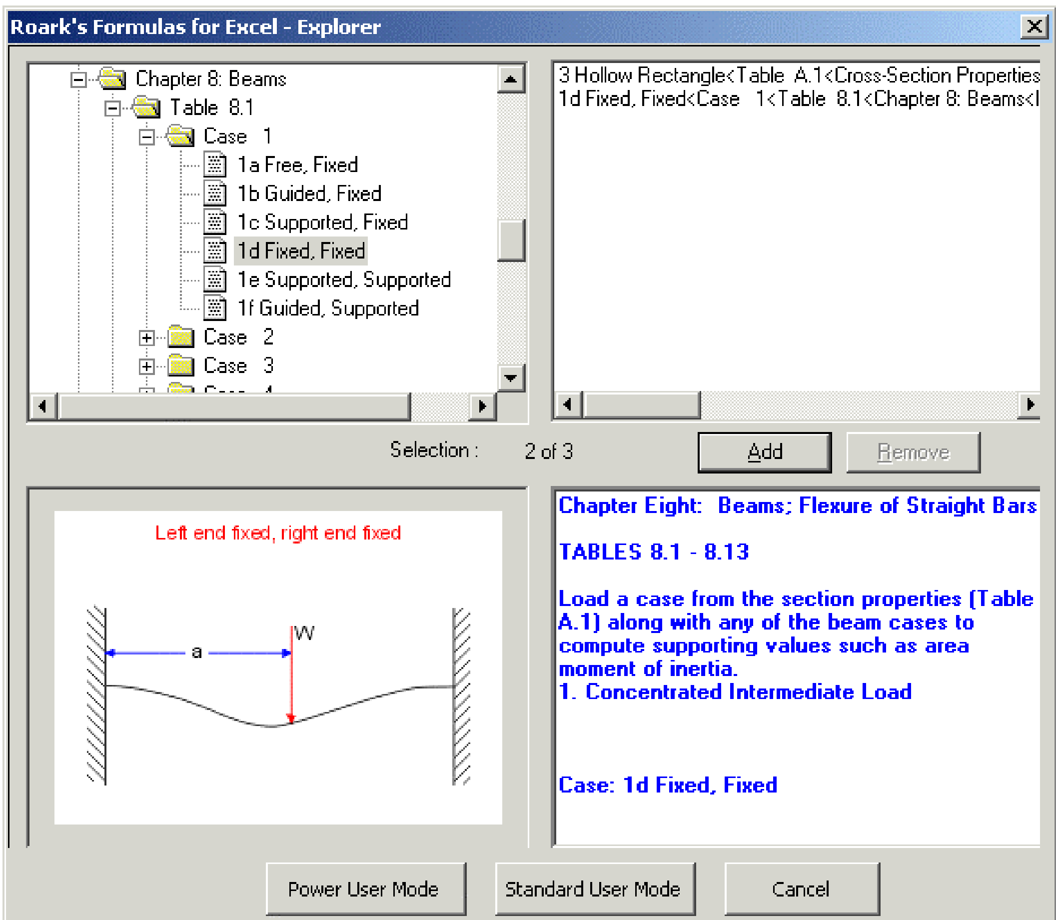
Tutorials will use the **Standard User Mode** to highlight the simplicity in using this software. Advanced Users may want to use the **Power User Mode** and examples are shown at the end of each Tutorial.

All Tutorials are shown with the US unit system.

Problem 2

Let's extend Problem 1 by adding beam support and load information. Specifically, assume that the beam will be steel, 6 ft long, fixed at both ends, with a maximum concentrated load of 2000 lbf at the center. You want to determine the deflection and stress values.

Open the Roark's Formulas for Excel Explorer and select **Table A.1**, **Case 3** (hollow rectangular cross-section). Then select **Table 8.1**, **Case 1d** and add this to the previous case selection.

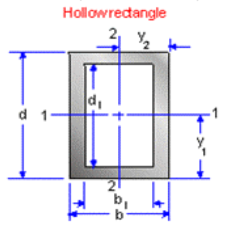


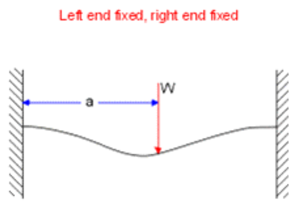
Click the **Standard User Mode** button to continue.

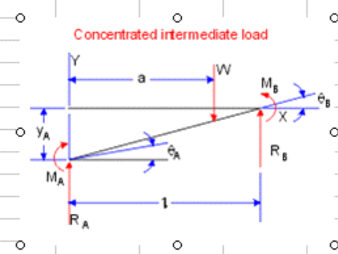
Once loaded into Excel the Worksheet looks as follows:

Roark's Formulas for Excel

Appendix: Properties of a Plane Area TABLE A.1
Table A.1 - Properties of Sections Pages 802 - 812
Case: 3 Hollow Rectangle
Chapter Eight: Beams; Flexure of Straight Bars TABLES 8.1 - 8.13
1. Concentrated Intermediate Load
Case: 1d Fixed, Fixed

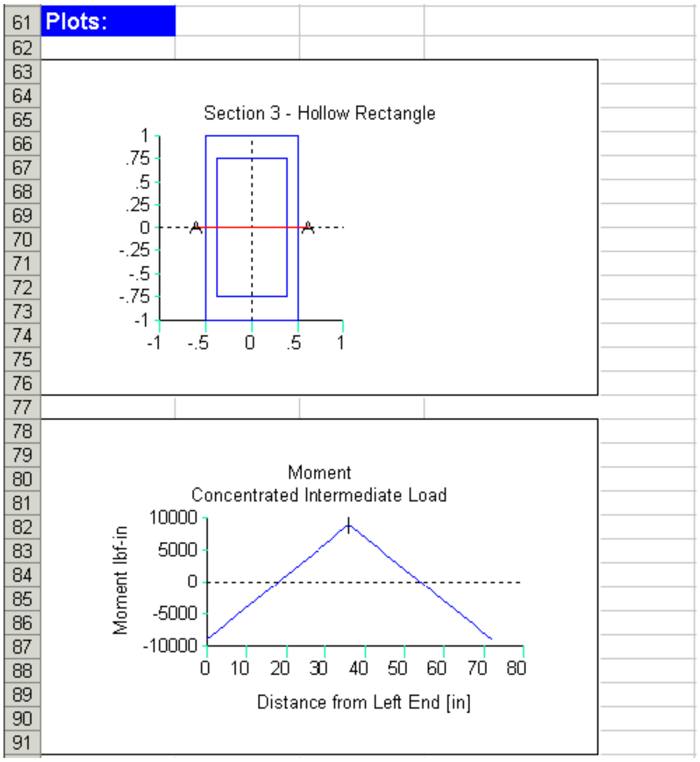






Input	Value	Unit	Comment
axis	1		Neutral Axis (1,2)
t1b	1	in	Side b
t1bi	0.75	in	Hollow Side bi
t1d	2	in	Side d
t1di	1.5	in	Hollow Side di
matnum	17		Material number (see material table)
L	72	in	Length of beam
a	36	in	Load distance from left end
W	1000	lbf	Load
x	36	in	Sample distance, x, from left end

Output	Value	Unit	Comment
A	0.875	in^2	Area, A
t1y	1	in	Centroid to Extremity, y
I	0.455729167	in^4	Area moment of inertia
I%c	0.455729167	in^3	Elastic section modulus
t1r	0.721687836	in	Radius of Gyration, r
Z	0.578125	in^3	Plastic Section Modulus, Z
SF	1.268571429		Shape Factor, SF
t	2	in	Depth
K	0.26796875	in^4	Torsional Stiffness Constant, K
Q	0.765625	in^3	Shear Stress Constant, Q
Q1	0.3828125	in^3	Shear Stress Constant, Long Side, Q1
matl	"Steel - A.S.T.M. A7-61T"		Material description
E	29000000	psi	Young's Modulus
V	500	lbf	Transverse shear at x
M	9000	lbf-in	Bending moment at x
theta	0	rad	Slope Angle at x
y	-0.147092808	in	Deflection at x
sty	19748.57143	psi	Max fiber stress at extremity at location x
RA	500	lbf	Vertical reaction at left end
MA	-9000	lbf-in	Bending moment at left end
thetaA	0	rad	Slope Angle at left end
yA	0	in	Deflection at left end
RB	500	lbf	Vertical reaction at right end
MB	-9000	lbf-in	Bending moment at right end
thetaB	0	rad	Slope angle at right end
yB	0	in	Deflection at right end



Now, enter the cross section dimensions in the Worksheet. Simply move to the Value column of the relevant variable and enter the data.

Neutral Axis	**1**
Side b	**1.5** in
Hollow side bi	**1.3125** in
Side d	**2.75** in
Hollow side di	**2** in

Note the revised Excel Worksheet.

Roark's Formulas for Excel

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1. Concentrated Intermediate Load
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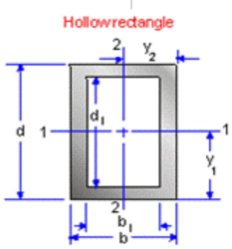
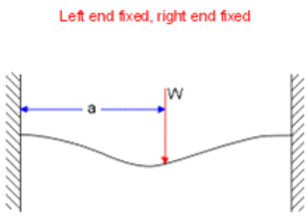
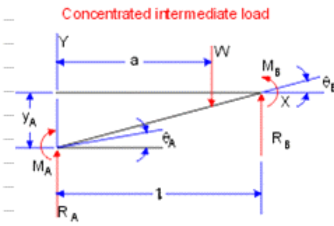
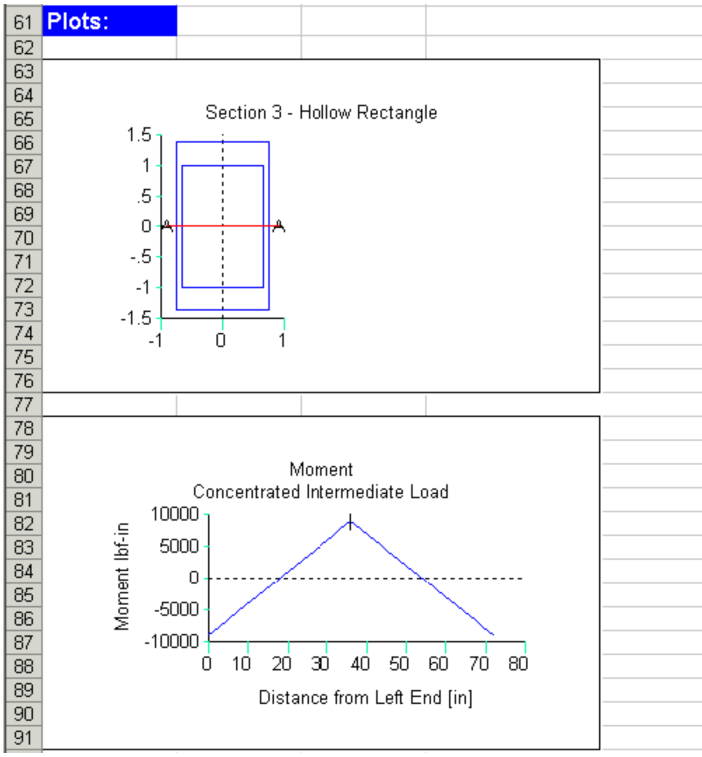






Input	Value	Unit	Comment
axis	1		Neutral Axis (1,2)
t1b	1.5	in	Side b
t1bi	1.3125	in	Hollow Side bi
t1d	2.75	in	Side d
t1di	2	in	Hollow Side di
matnum	17		Material number (see material table)
L	72	in	Length of beam
a	36	in	Load distance from left end
W	1000	lbf	Load
x	36	in	Sample distance, x, from left end

Output	Value	Unit	Comment
A	1.5	in^2	Area, A
t1y	1.375	in	Centroid to Extremity, y
I	1.724609375	in^4	Area moment of inertia
I%c	1.254261364	in^3	Elastic section modulus
t1r	1.072259103	in	Radius of Gyration, r
Z	1.5234375	in^3	Plastic Section Modulus, Z
SF	1.214609287		Shape Factor, SF
t	2.75	in	Depth
K	0.767075503	in^4	Torsional Stiffness Constant, K
Q	2.504882813	in^3	Shear Stress Constant, Q
Q1	0.626220703	in^3	Shear Stress Constant, Long Side, Q1
matl	"Steel - A.S.T.M. A7-61T"		Material description
E	29000000	psi	Young's Modulus
V	500	lbf	Transverse shear at x
M	9000	lbf-in	Bending moment at x
theta	0	rad	Slope Angle at x
y	-0.038869372	in	Deflection at x
sty	7175.537939	psi	Max fiber stress at extremity at location x
RA	500	lbf	Vertical reaction at left end
MA	-9000	lbf-in	Bending moment at left end
thetaA	0	rad	Slope Angle at left end
yA	0	in	Deflection at left end
RB	500	lbf	Vertical reaction at right end
MB	-9000	lbf-in	Bending moment at right end
thetaB	0	rad	Slope angle at right end
yB	0	in	Deflection at right end


Plots:
Section 3 - Hollow Rectangle
Moment
Concentrated Intermediate Load
Moment lbf-in
Distance from Left End [in]

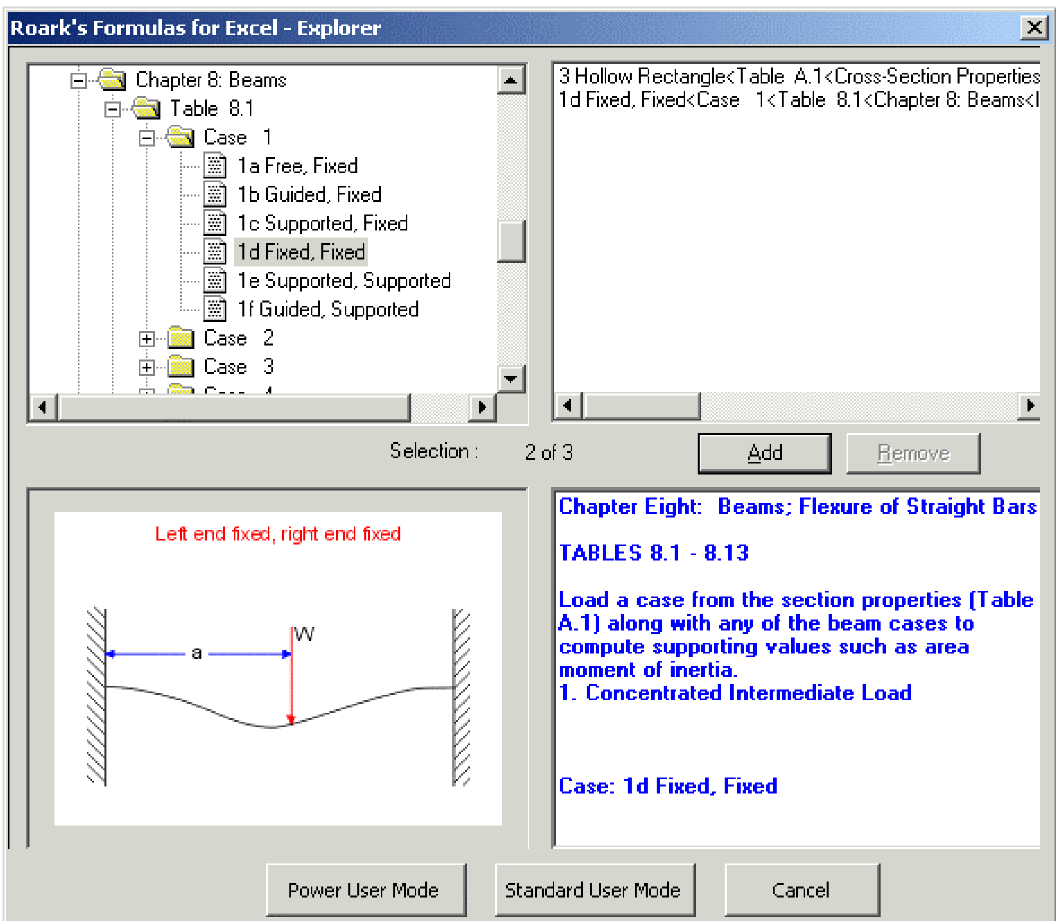
Power User Mode Approach

The following series of problems uses the Power User Mode approach in the Roark's Formulas for Excel Explorer.

Problem 2

Let's extend Problem 1 by adding beam support and load information. Specifically, assume that the beam will be steel, 6 ft long, fixed at both ends, with a maximum concentrated load of 2000 lbf at the center. You want to determine the deflection and stress values.

Open the Roark's Formulas for Excel Explorer and select **Table A.1**, **Case 3** (hollow rectangular cross-section). Then select **Table 8.1**, **Case 1d** and add this to the previous case selection. Click the **Power User Mode** button.



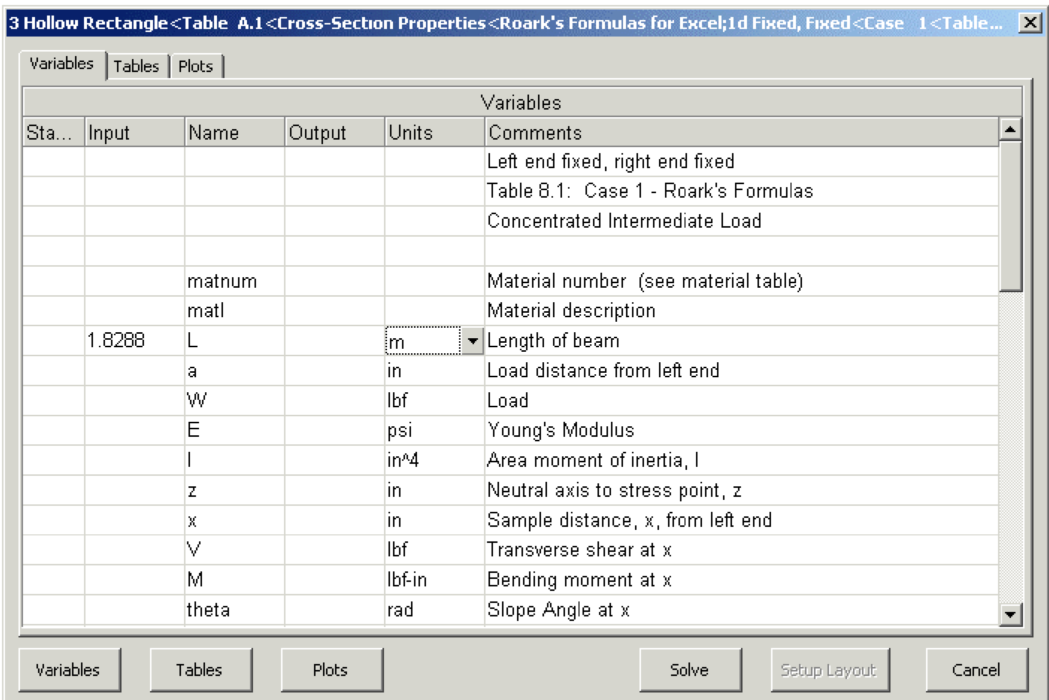
This combines the cross section variables and formulas with the beam loading formulas and opens an Input form having the combined Variables, Tables and Plots tabs as shown below.

First, enter the cross section dimensions as done in Problem 1.

Neutral Axis	**1**
Side b	**1.5** in
Hollow side bi	**1.3125**
Side d	**2.75** in
Hollow side di	**2** in
Length	**6** ft (1.828 m)

Enter a length of 6 m and then change the unit from ft to m simply highlight the unit and select the appropriate unit.

Roark’s Formulas for Excel supports unit conversions for a wide range of quantities used in the application.



Sta...	Input	Name	Output	Units	Comments
					Left end fixed, right end fixed
					Table 8.1: Case 1 - Roark's Formulas
					Concentrated Intermediate Load
		matnum			Material number (see material table)
		matl			Material description
	1.8288	L		m	Length of beam
		a		in	Load distance from left end
		W		lbf	Load
		E		psi	Young's Modulus
		I		in^4	Area moment of inertia, I
		z		in	Neutral axis to stress point, z
		x		in	Sample distance, x, from left end
		V		lbf	Transverse shear at x
		M		lbf-in	Bending moment at x
		theta		rad	Slope Angle at x

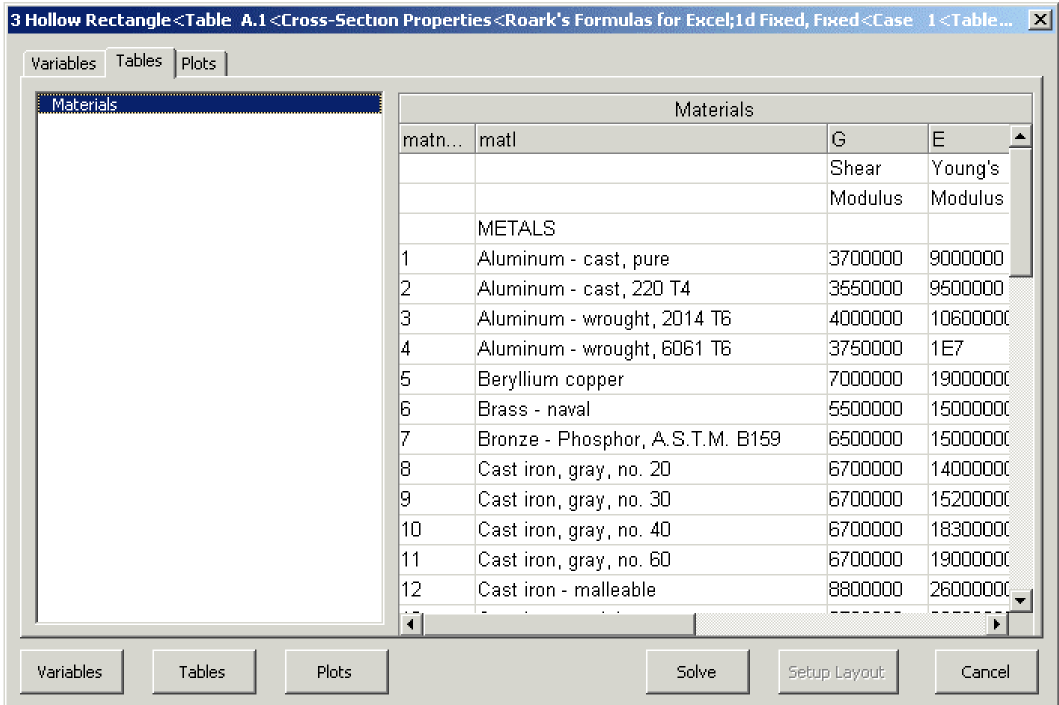
Enter the inputs for the remaining variables:

Load distance from left end	**36** in
Load	**2000** lbf
Young’s Modulus	**3E7** psi

Distance x is the location along the beam at which the shear, moment, slope, deflection, and stress will be calculated and reported. By default, the model automatically solves for the two ends. By entering a value for x, you also get a solution at the desired location.

If you don’t remember the Young’s Modulus for steel, you can check the Material Properties Table, which is automatically loaded with each case. You can look at the Material Properties Table by clicking the Tables Tab and selecting Materials.

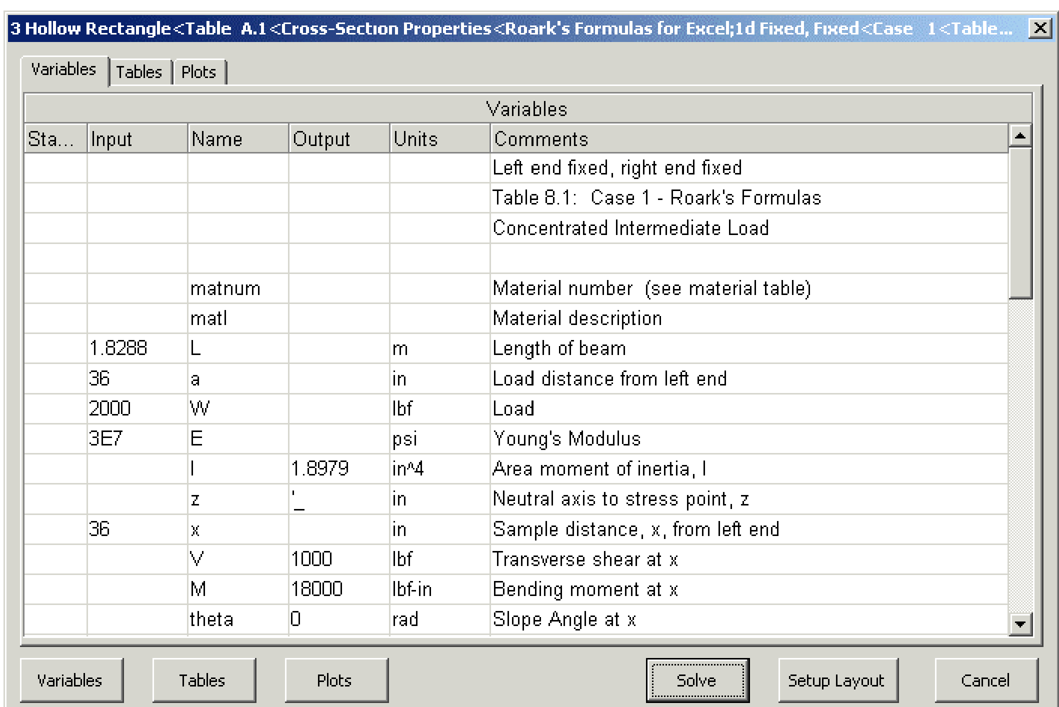
The table appears as shown below.



matn...	matl	G	E
		Shear	Young's
		Modulus	Modulus
	METALS		
1	Aluminum - cast, pure	3700000	9000000
2	Aluminum - cast, 220 T4	3550000	9500000
3	Aluminum - wrought, 2014 T6	4000000	10600000
4	Aluminum - wrought, 6061 T6	3750000	1E7
5	Beryllium copper	7000000	19000000
6	Brass - naval	5500000	15000000
7	Bronze - Phosphor, A.S.T.M. B159	6500000	15000000
8	Cast iron, gray, no. 20	6700000	14000000
9	Cast iron, gray, no. 30	6700000	15200000
10	Cast iron, gray, no. 40	6700000	18300000
11	Cast iron, gray, no. 60	6700000	19000000
12	Cast iron - malleable	8800000	26000000

The material number appears in the left column. This is the value you input for the variable `matnum`. The program will then retrieve the required values from the row of the table. We could use material number 17 for steel in this example.

Click the Solve button and the results are shown.

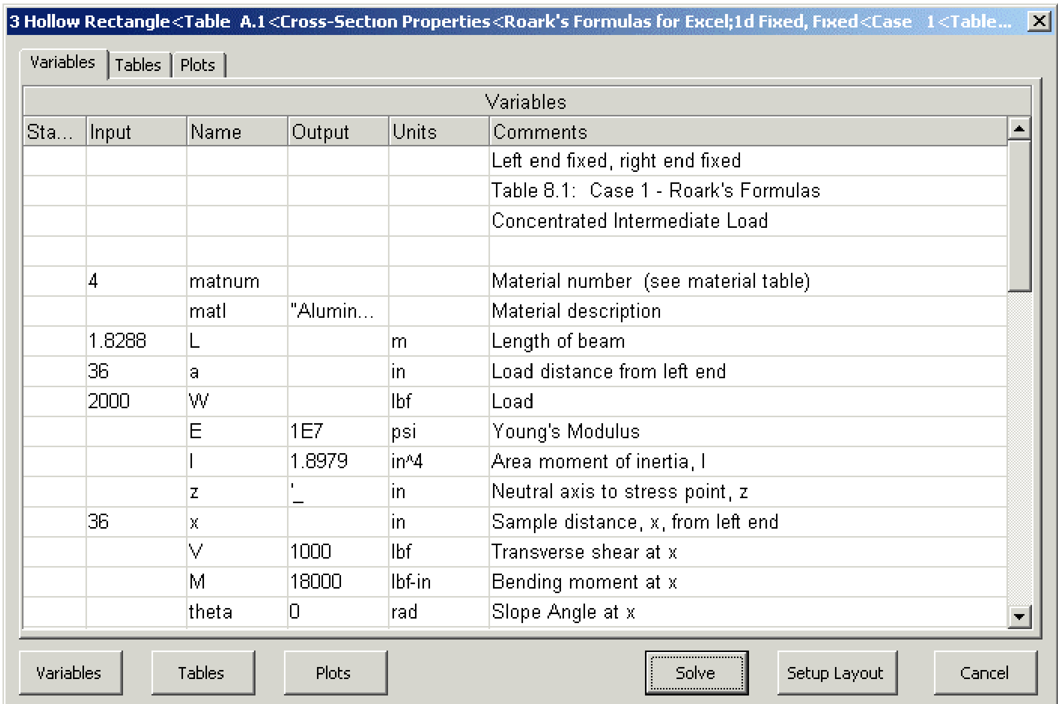


Sta...	Input	Name	Output	Units	Comments
					Left end fixed, right end fixed
					Table 8.1: Case 1 - Roark's Formulas
					Concentrated Intermediate Load
		matnum			Material number (see material table)
		matl			Material description
	1.8288	L		m	Length of beam
	36	a		in	Load distance from left end
	2000	W		lbf	Load
	3E7	E		psi	Young's Modulus
		I	1.8979	in^4	Area moment of inertia, I
		z	'_	in	Neutral axis to stress point, z
	36	x		in	Sample distance, x, from left end
		V	1000	lbf	Transverse shear at x
		M	18000	lbf-in	Bending moment at x
		theta	0	rad	Slope Angle at x

Let's change the beam material from steel to aluminum. Select the Tables tab and view the Materials Table again. Notice that materials 1-4 are various types of aluminum. Use number 4. Select the Variables tab and enter **4** as an input for the variable named `matnum`.

Blank the current value for the Young's Modulus `E`.

Solve and view the results.



The change in materials has significantly increased the deflection at x.

Now select Setup Layout and load the model in the Excel Worksheet.

Roark's Formulas for Excel

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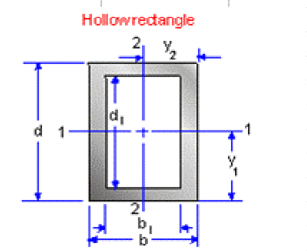
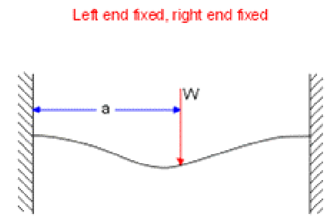
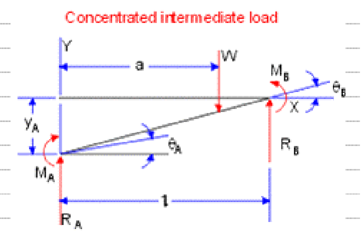
1. Concentrated Intermediate Load
Case: 1d Fixed, Fixed



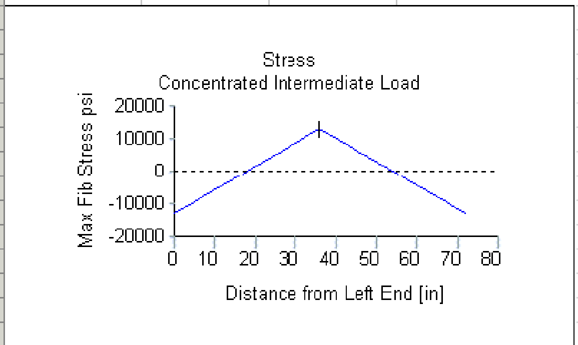


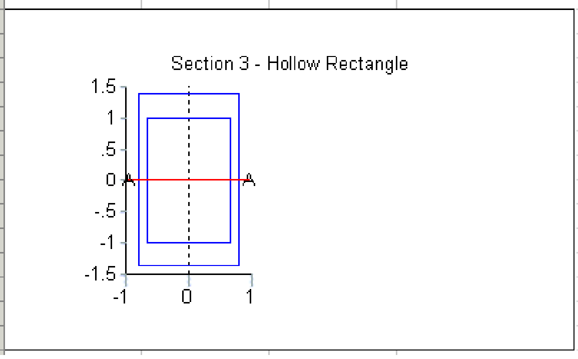


Input	Value	Unit	Comment
matnum	4		Material number (see material table)
L	1.8288	m	Length of beam
a	36	in	Load distance from left end
W	2000	lbf	Load
E	3.00E+07	psi	Young's Modulus
x	36	in	Sample distance, x, from left end
axis	1		Neutral Axis (1,2)
t1b	1.6	in	Side b
t1bi	1.3125	in	Hollow Side bi
t1d	2.75	in	Side d
t1di	2	in	Hollow Side di

Output	Value	Unit	Comment
matl	"Aluminum - wrought, 6061 T6		Material description
I	1.897916667	in^4	Area moment of inertia, I
z	'_	in	Neutral axis to stress point, z
V	1000	lbf	Transverse shear at x
M	18000	lbf-in	Bending moment at x
theta	0	rad	Slope Angle at x
y	-0.068285401	in	Deflection at x
st	'_	psi	Fiber stress at stress point z at location x
sty	13040.61471	psi	Max fiber stress at extremity at location x
RA	1000	lbf	Vertical reaction at left end
MA	-18000	lbf-in	Bending moment at left end
thetaA	0	rad	Slope Angle at left end
yA	0	in	Deflection at left end
RB	1000	lbf	Vertical reaction at right end
MB	-18000	lbf-in	Bending moment at right end
thetaB	0	rad	Slope angle at right end
yB	0	in	Deflection at right end
A	1.775	in^2	Area, A
t1y	1.375	in	Centroid to Extremity, y
I%c	1.38030303	in^3	Elastic Section Modulus, I/c
t1r	1.034044886	in	Radius of Gyration, r
Z	1.7125	in^3	Plastic Section Modulus, Z
SF	1.240669594		Shape Factor, SF
t	2.75	in	Depth
K	1.172440897	in^4	Torsional Stiffness Constant, K
Q	2.593945313	in^3	Shear Stress Constant, Q
Q1	0.994345703	in^3	Shear Stress Constant, Long Side, Q1

Plots:


Stress
Concentrated Intermediate Load
Max Fib Stress psi
20000
10000
0
-10000
-20000
0 10 20 30 40 50 60 70 80
Distance from Left End [in]


Section 3 - Hollow Rectangle
1.5
1
.5
0
-.5
-1
-1.5
-1 0 1
A
A