



Mek-Mat *Power*

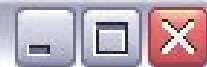
Version 5.12

Actus Potentia, Inc.

START

www.actuspotentia.com

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Stress/Strain Transformation

Stress Transformation

Mohr's Circle

Rosette Problems: Click "Concept Map"
and open stress-strain.mmf

Axial Loading

Axial Loading

Torsion Loading

Torsion Loading

Concept Map

Beam Bending

Beam Bending

Buckling

Buckling

Combined Loading

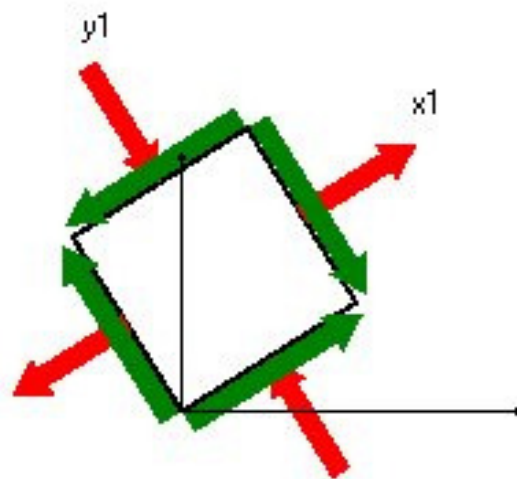
Combined Loading

Cylindrical Pressure Vessel

Click "Concept Map" and open
cyl_press_vess.mmf

Stress Transformation

Stress Transformation



Normal Stress (σ_x)

Normal Stress (σ_y)

Shear Stress (τ_{xy})

Calculate

Stress x_1

Stress y_1

Shear

Angle (degrees)



Change

Enter σ_x , σ_y , and τ_{xy} values. Click 'Calculate' to begin. Shift the dial towards right to rotate the coordinate system through an angle up to 90 degrees. Watch the stresses change in the rotated x_1 - y_1 system.

HELP

CLOSE

Mohr's Circle

Mohr's Circle - Main Screen

Vertical Surface Stress State

Normal stress (magnitude) Tension Compression

Shear stress (magnitude) CW CCW

Horizontal Surface Stress State

Normal stress (magnitude) Tension Compression

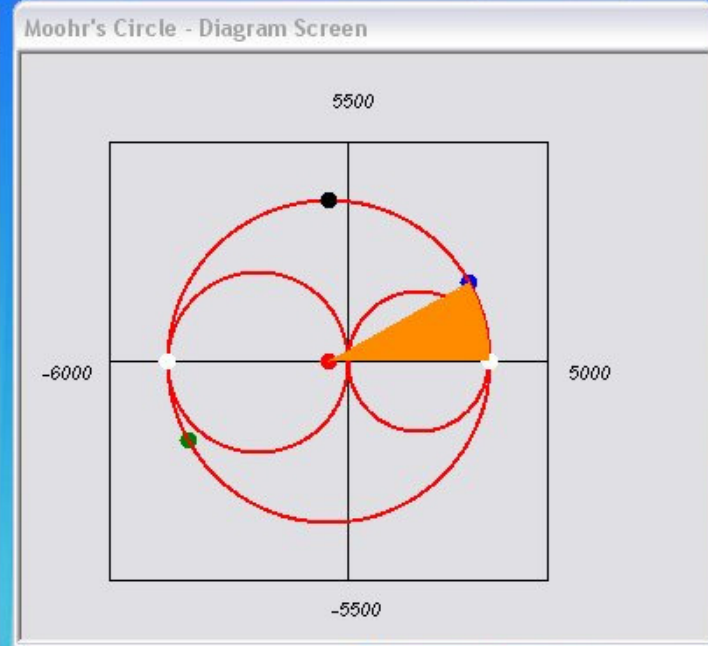
Sigma-Tau Coordinates of Stress States

	σ	τ	
Vertical surface	<input type="text" value="3000"/>	<input type="text" value="2000"/>	Correct
Horizontal Surface	<input type="text" value="-4000"/>	<input type="text" value="-2000"/>	Correct

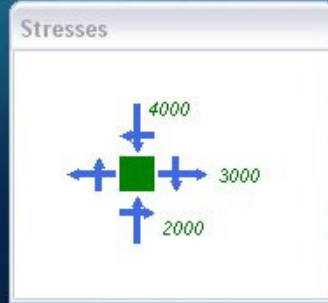
Enter circle properties

sigma value of center

radius of circle



- Labels**
- blue = vertical surface
 - green = horizontal surface
 - red = center of Mohr's circle
 - white = principal sigmas
 - brown = principal tau
 - black = tau-max



Axial Loading – Problem Definition

Axial Loading

Add Section Add Load

Select Boundary Condition Done!

Run Solution Wizard!

New Problem/Restart Calculator Close

Section				
	Area	Length	Composite	InnerArea
▶	5	48	No	0
	4	12	Yes	2

Load			
	Load	Direction	Distance
▶	2000	Right	24
	3000	Left	60

Clamped

Axial Loading – Queries to Lead User to the Solution Correct/Incorrect Feedback

SolutionWizard

End-points of segment ?	<input type="text" value="48"/>	<input type="text" value="64"/>	<input type="button" value="check"/>	Correct!	Enter outer force in segment:	<input type="text"/>	<input type="button" value="check"/>
Is segment:	<input type="text" value="Composite"/>		<input type="button" value="check"/>	Correct!			
Enter outer area for segment:	<input type="text" value="2"/>		<input type="button" value="check"/>	Correct!			
Enter outer E for segment:	<input type="text" value="14e6"/>		<input type="button" value="check"/>	Correct!			
Enter inner area for segment:	<input type="text" value="1"/>		<input type="button" value="check"/>	Correct!			
Enter inner E for segment:	<input type="text" value="32e6"/>		<input type="button" value="check"/>	Correct!			
Enter force in segment:	<input type="text" value="-4000"/>		<input type="button" value="check"/>	Correct!			

+ = Tension

Axial Loading – Help

composite.pdf - Adobe Reader


File Edit View Window Help

1 / 2 100%

Tools Sign Comment

Example Problem:

A composite cantilever beam ($L=100\text{in}$) is axially loaded with a positive force of 2000 lbs. on its free, right end. The outer section of the beam is steel ($E=30\text{e}6$ psi) and has a cross-sectional area of 20 in^2 . The inner section of the beam is aluminum ($E=10\text{e}6$ psi) and has a cross-sectional area of 10 in^2 .



The diagram shows a composite cantilever beam fixed to a wall on the left. The beam is composed of three horizontal layers: a top layer (steel), a middle layer (aluminum), and a bottom layer (steel). A force P is applied to the right end of the beam. A dimension line below the beam indicates a length of 100 inches.

Torsion Loading – Problem Definition

Torsional loading of shafts

Add section

Add torque

Apply BC

Done!

Run solution wizard

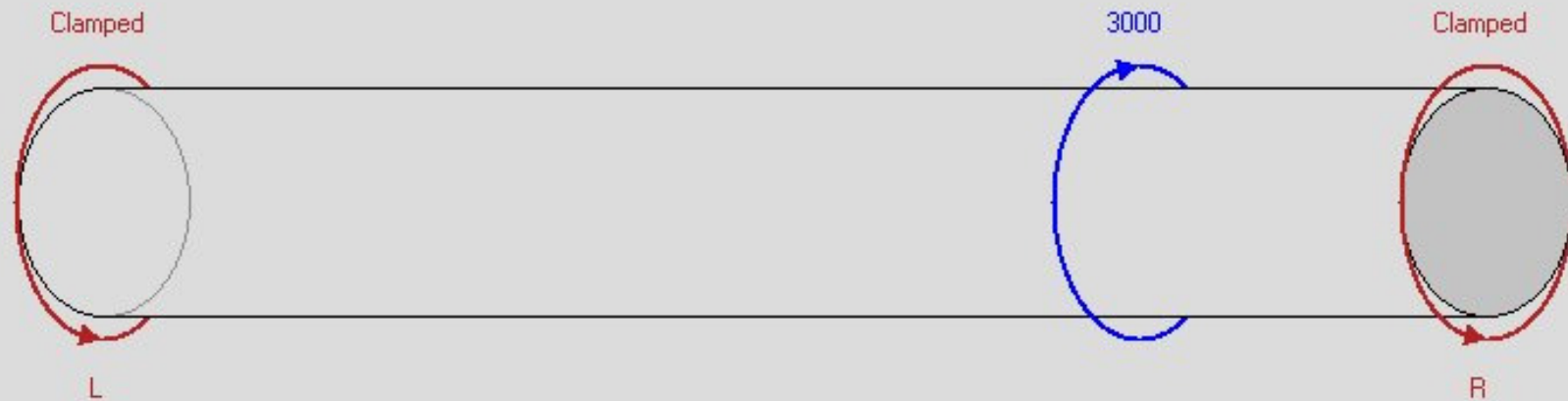
Section					
	Diameter	Length	Composite	InnerDiam	ShearMod1
▶	3	48	No	N/A	32e6

Torque			
	Torque	Orientation	Dis
▶	3000	CW	36

Restart/New Problem

Calculator

Close



Torsion Loading – Queries to Lead User to the Solution Message Boxes for Guidance

Torsional loading of shafts

Add section Add torque
Apply BC Done!

Section					
	Diameter	Length	Composite	InnerDiam	ShearMod1
▶	3	48	No	N/A	32e6

Torque			
	Torque	Orientation	Dis
▶	3000	CW	36

Restart/New Problem Calculator Close

SolutionWizard

How many segments?

Cancel Help

torsion

First, solve as determinate problem with right clamp removed.

Torsion Loading – Queries to Lead User to the Solution Correct/Incorrect Feedback

Torsional loading of shafts

Add section Add torque

Apply BC Done!

Section					
	Diameter	Length	Composite	InnerDiam	ShearMod1
▶	3	48	No	N/A	32e6

Torque			
	Torque	Orientation	Dis
▶	3000	CW	36

Restart/New Problem Calculator Close

The diagram shows a horizontal shaft. At the left end (labeled 'L'), there is a red circular arrow labeled 'Clamped'. At the right end (labeled 'R'), there is also a red circular arrow labeled 'Clamped'. In the middle of the shaft, there is a blue circular arrow labeled '3000'.

SolutionWizard

End-points of segment 2: 36 48 check Correct!

Is segment: Neither check Correct!

Enter J for segment: check

Cancel Help

Torsion Loading – Help

indeterminatetorsion.pdf - Adobe Reader

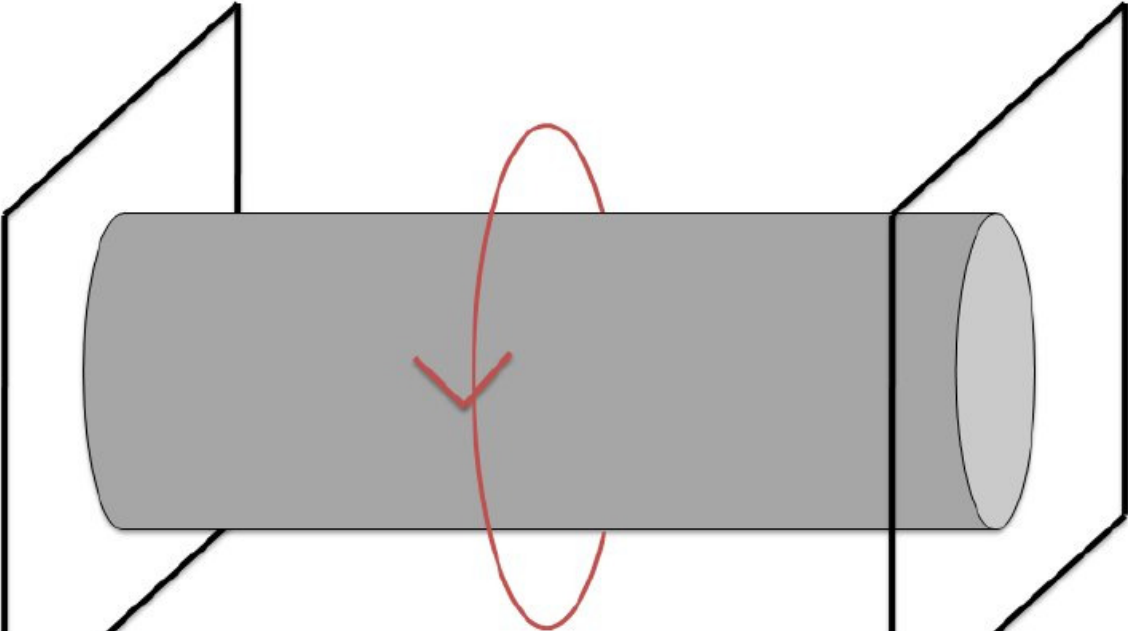
File Edit View Window Help

1 / 5 100%

Tools Sign Comment

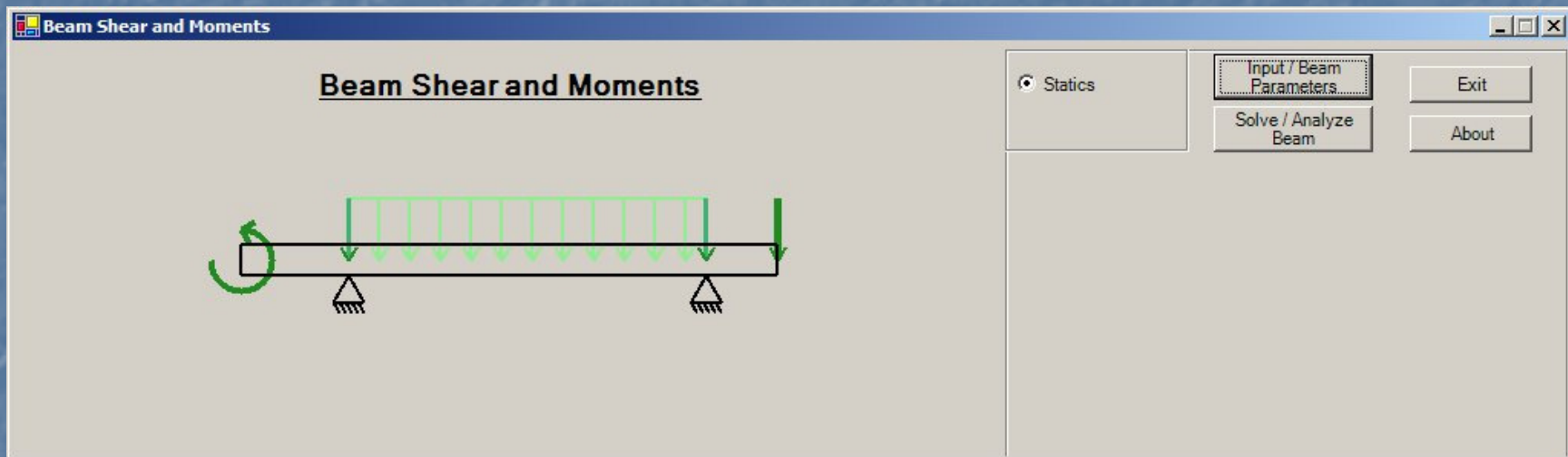
Example Problem:

A uniform bar ($L=60\text{in}$) is clamped at each end. A load $P=2000\text{in}\cdot\text{lb}$ is applied to the right at a point $x=30\text{in}$ from the left clamp. The bar is made of steel ($G=11.5\text{e}6\text{ psi}$) and has a diameter of 2 in.

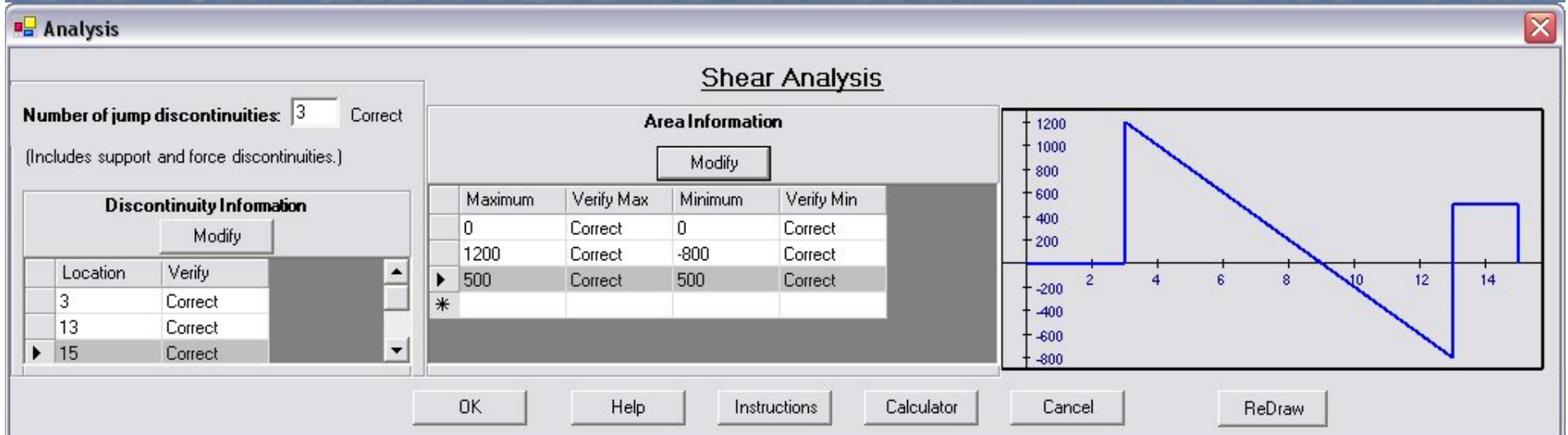


The diagram shows a horizontal cylindrical bar of length $L=60\text{in}$. The bar is clamped at both ends, indicated by two vertical lines extending upwards from the bar's ends. A red arrow is drawn around the bar, pointing to the right, representing a torsional load $P=2000\text{in}\cdot\text{lb}$ applied at a point $x=30\text{in}$ from the left clamp. The bar is shaded gray, and the clamping mechanism is shown in black.

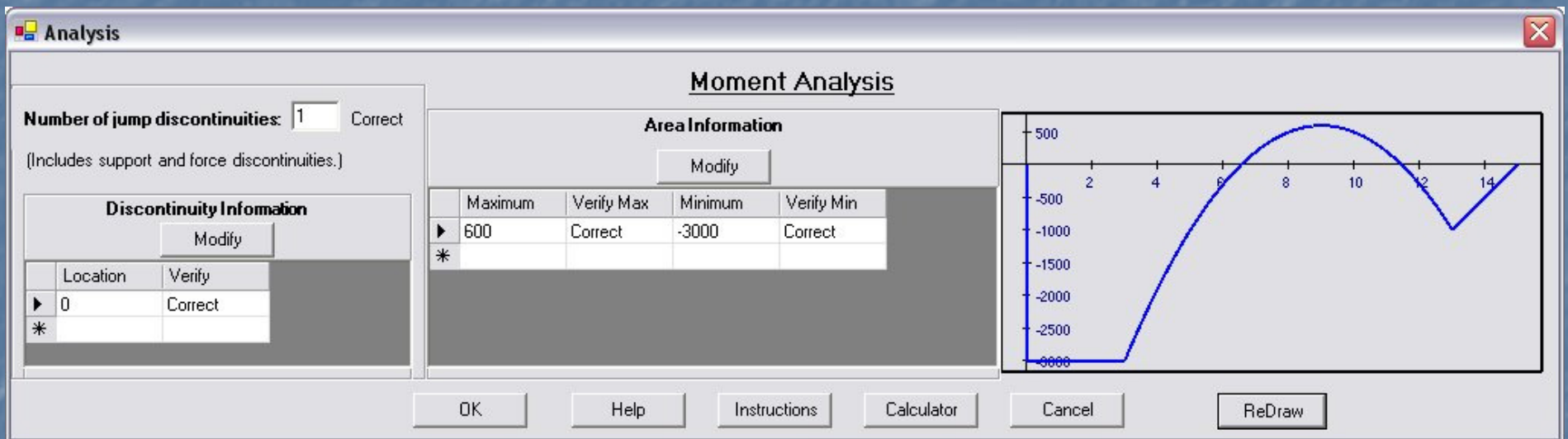
Bending – Problem Definition



Beam Shear – Queries to Lead User to the Solution Correct/Incorrect Feedback



Beam Bending Moment – Queries to Lead User to the Solution Correct/Incorrect Feedback



Buckling

Column Buckling

Select number of digits accuracy

1 digit

2 digits

3 digits

Select

Select Supports

Pin-Pin

Fixed-Pin

Fixed-Fixed

Fixed-Free

Enter length of column TRUE!

Enter EFFECTIVE length of column Check Help

Enter minimum 2nd moment of Area. Enter

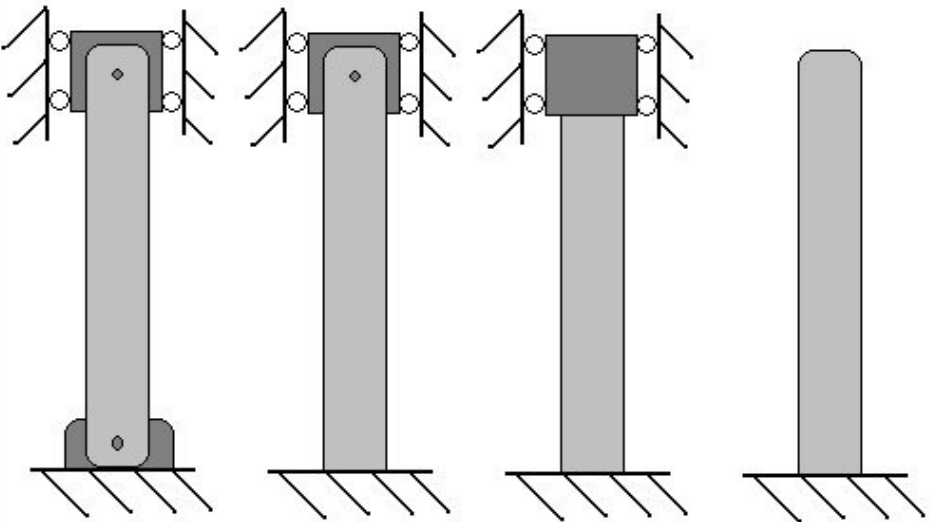
Enter modulus of elasticity, E

Find moment of inertia with section properties calculator

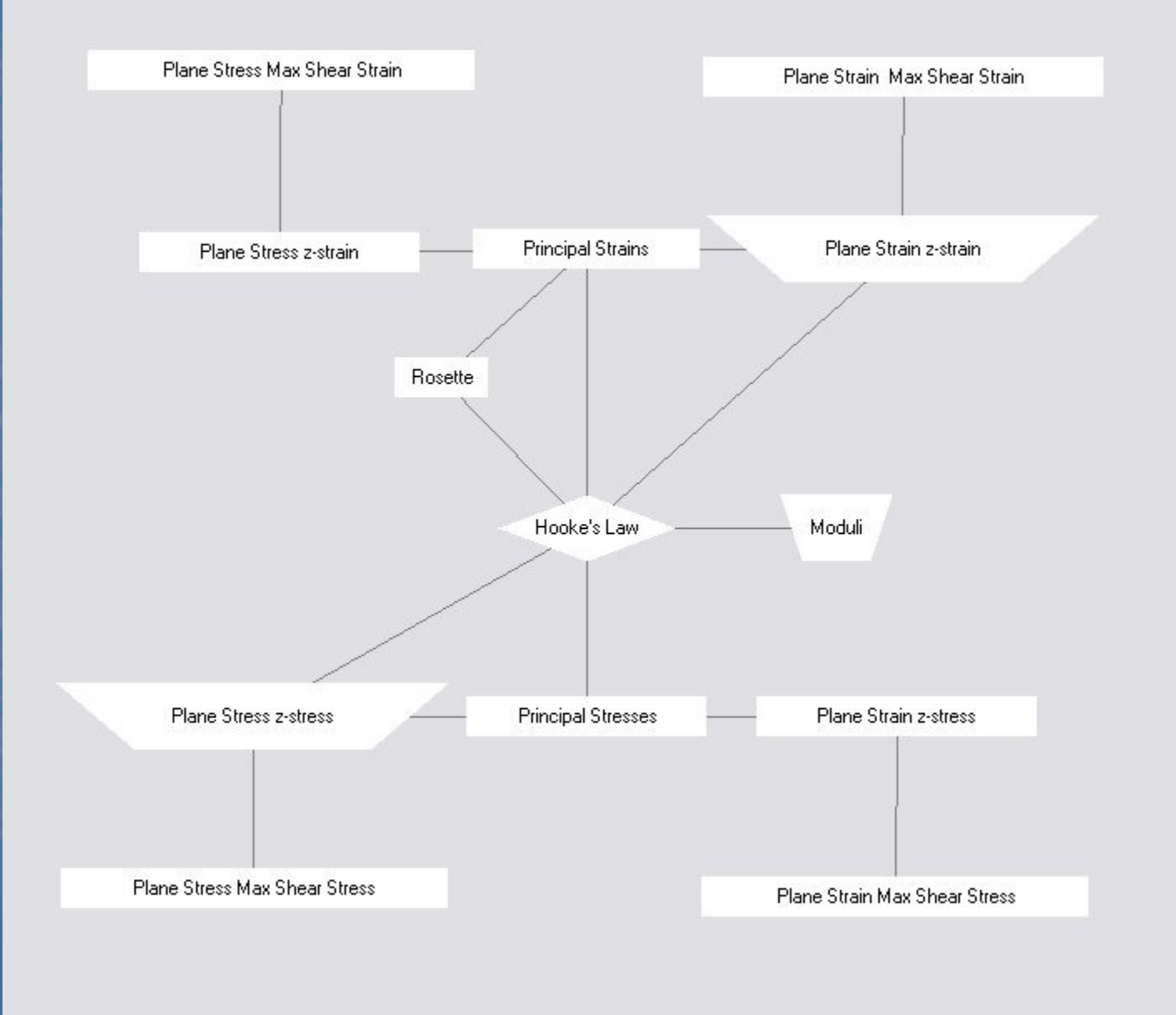
Copy minimum value from section properties calculator!

Calculator

Close



Concept Map – Rosette & Principal Stress/Strain



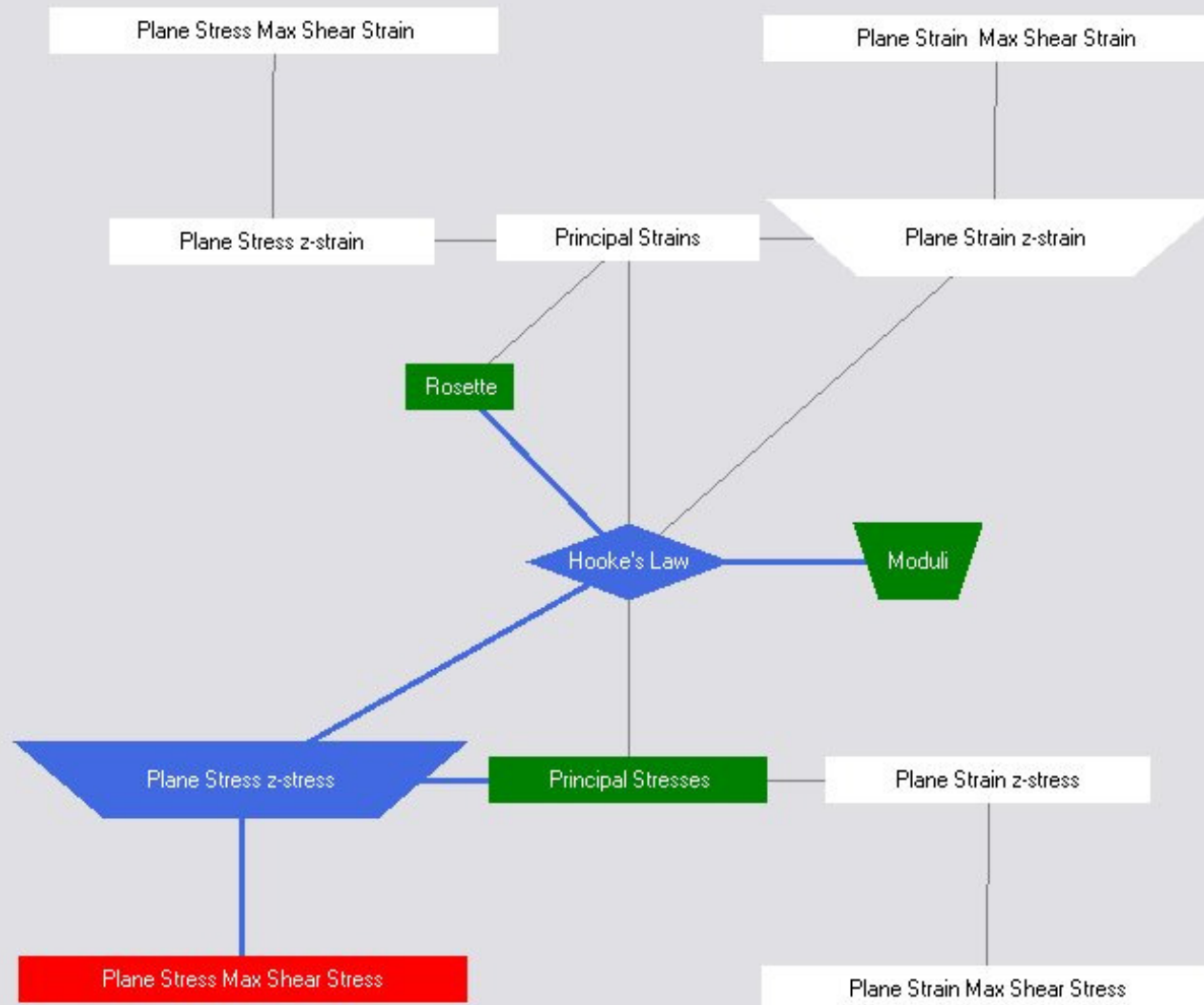
Concept Map – Variable List

Displaying all variables in map

Accept Changes (Enter) Discard Changes (Esc) Add Other Variables Basic ▾

KNOWN variables	DESIRED variables
Check all the variables you know.	Check the one variable you need.
<input checked="" type="checkbox"/> Angle-a - theta_a	<input type="radio"/> Angle-a - theta_a
<input checked="" type="checkbox"/> Angle-b - theta_b	<input type="radio"/> Angle-b - theta_b
<input checked="" type="checkbox"/> Angle-c - theta_c	<input type="radio"/> Angle-c - theta_c
<input checked="" type="checkbox"/> Poisson's Ratio - nu	<input type="radio"/> Poisson's Ratio - nu
<input type="checkbox"/> Shear Modulus - G	<input type="radio"/> Shear Modulus - G
<input type="checkbox"/> Shear strain - gxy	<input type="radio"/> Shear strain - gxy
<input type="checkbox"/> Shear stress - txy	<input type="radio"/> Shear stress - txy
<input checked="" type="checkbox"/> Strain-a - ea	<input type="radio"/> Strain-a - ea
<input checked="" type="checkbox"/> Strain-b - eb	<input type="radio"/> Strain-b - eb
<input checked="" type="checkbox"/> Strain-c - ec	<input type="radio"/> Strain-c - ec
<input type="checkbox"/> x-strain - ex	<input type="radio"/> x-strain - ex
<input type="checkbox"/> x-stress - sx	<input type="radio"/> x-stress - sx
<input checked="" type="checkbox"/> Young's Modulus - E	<input type="radio"/> Young's Modulus - E
<input type="checkbox"/> y-strain - ey	<input type="radio"/> y-strain - ey
<input type="checkbox"/> y-stress - sy	<input type="radio"/> y-stress - sy
<input type="checkbox"/> z-strain - ez	<input type="radio"/> z-strain - ez
<input type="checkbox"/> z-stress - sz	<input type="radio"/> z-stress - sz

Concept Map – Solution Path



Concept Map – Solution Steps

Step 1: Solved variable "Shear Modulus" in equation "Moduli"

Step 2: Solved variable "z-stress" in equation "Plane Stress z-stress"

Step 3: Solved variable "x-strain" in equation "Rosette"

Step 3: Solved variable "y-strain" in equation "Rosette"

Step 3: Solved variable "Shear strain" in equation "Rosette"

Step 4: Solved variable "Shear stress" in equation "Hooke's Law"

Step 5: Solved variable "x-stress" in equation "Hooke's Law"

Step 5: Solved variable "y-stress" in equation "Hooke's Law"

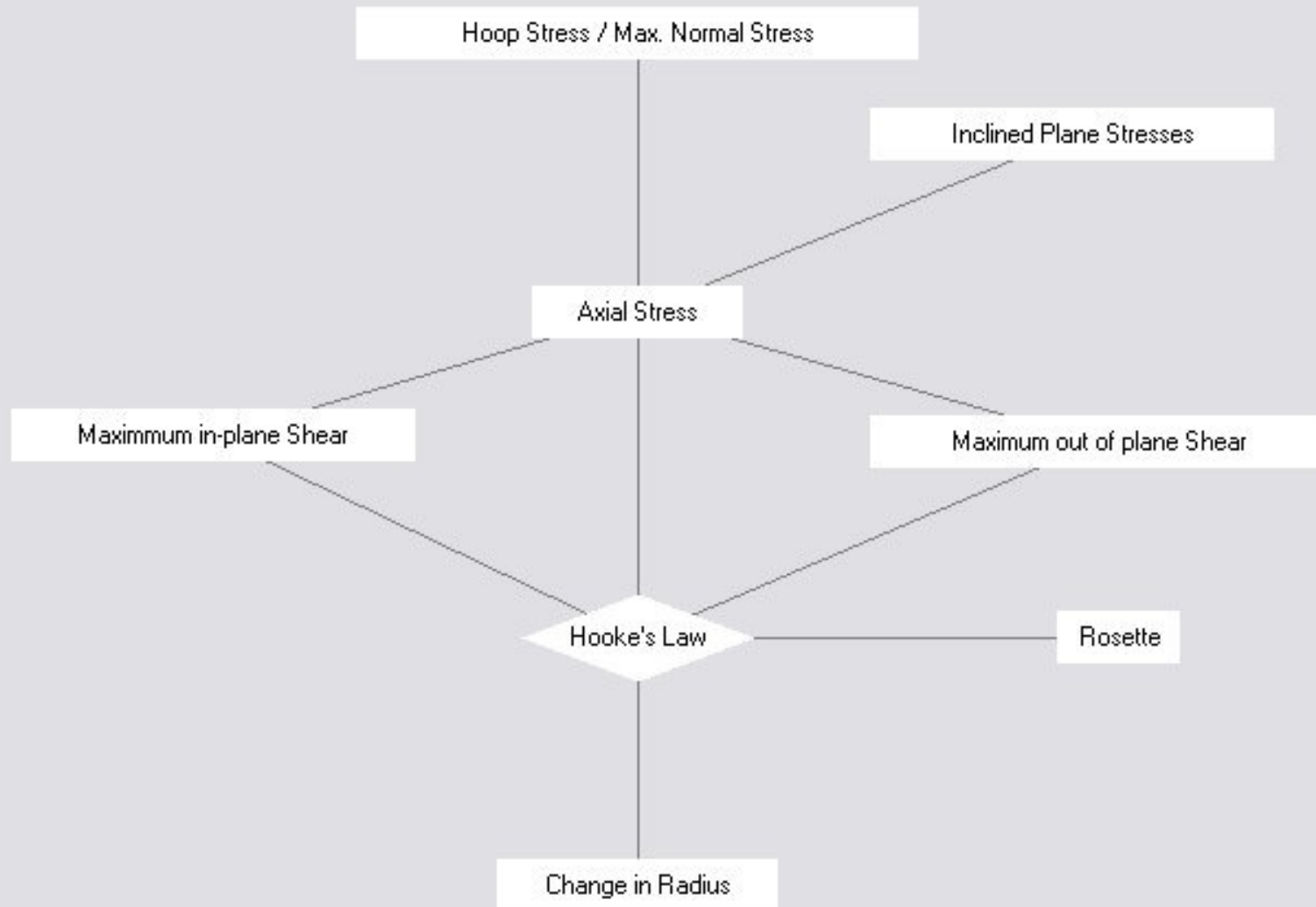
Step 6: Solved variable "Principal shear stress" in equation "Principal Stresses"

Step 7: Solved variable "Principal stress-2" in equation "Principal Stresses"

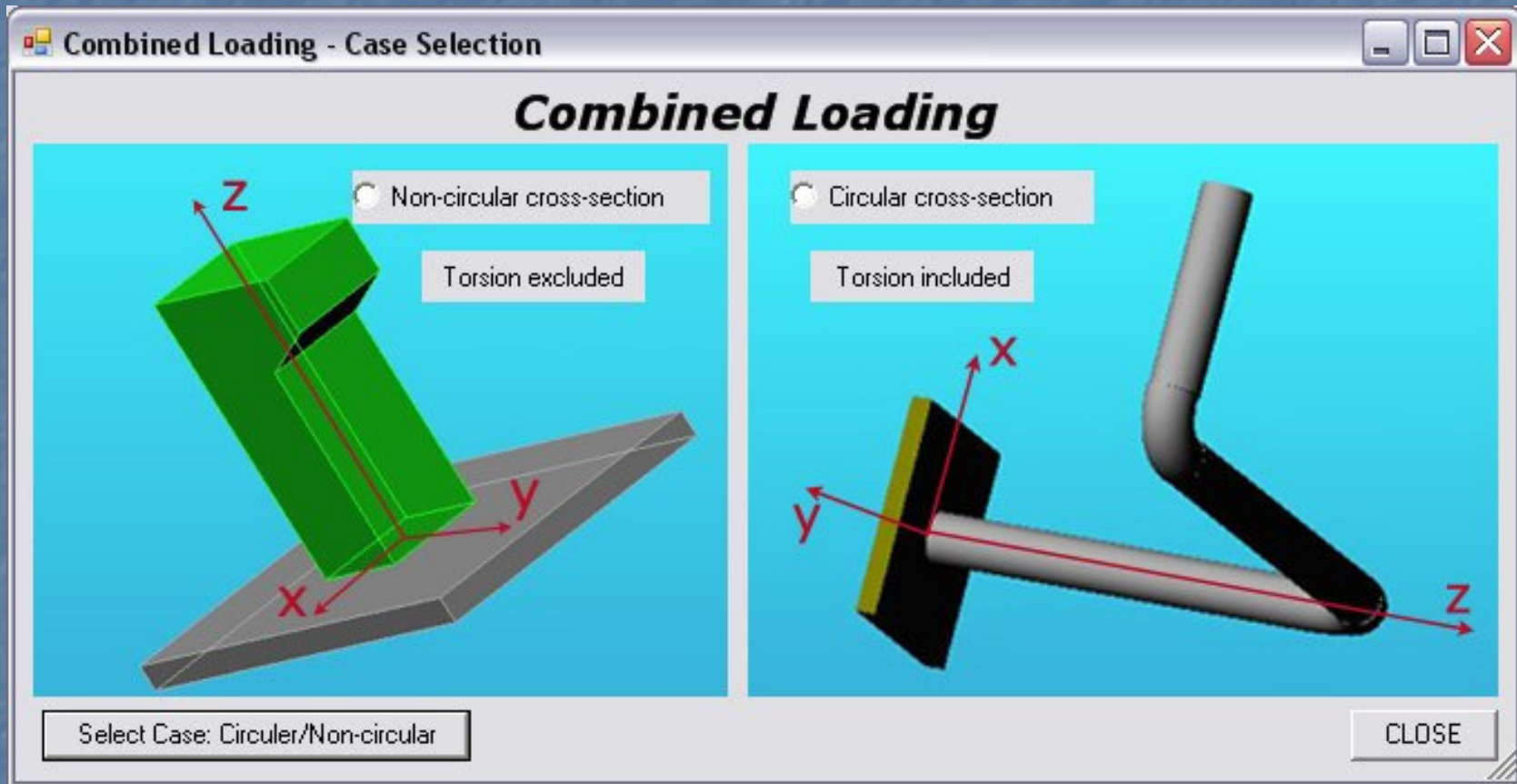
Step 8: Solved variable "Principal stress -1" in equation "Principal Stresses"

Step 9: Solved variable "z-strain" in equation "Hooke's Law"

Concept Map – Cylindrical Pressure Vessel

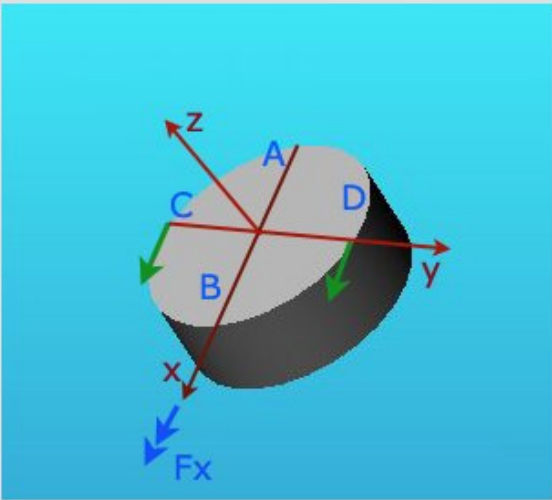


Combined Loading



Combined Loading – Queries that Lead User to Solution

Circular Cross Section



Components of r:

Components of F:
 F_x F_y F_z

Shaft Radius: Inner Outer

Components of Moment at cut:
 M_x M_y M_z

F_x - Shear
 F_y - Shear
 F_z - Axial
 M_x - Bending
 M_y - bending
 M_z - Torsion

For shear due to F_x , which is the neutral axis?
 AB CD

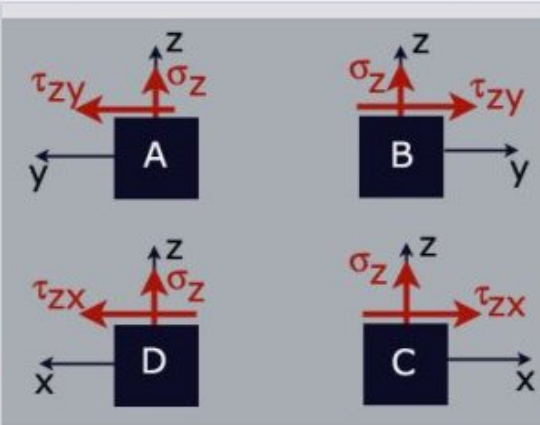
Zero stress at: A B C D

 Correct

F_x Shear : Shear Stress
 Enter magnitude of stress
 Correct

Q
 I
 t
 J
 Area

Circular Cross Section - Stress at points



Force F_x

A shear(z)	<input type="text" value="0.000e+000"/>
B shear(z)	<input type="text" value="0.000e+000"/>
C shear(z)	<input type="text" value="9.431e+001"/>
D shear(z)	<input type="text" value="9.431e+001"/>

Moment M_x

A sigma(z)	<input type="text"/>
B sigma(z)	<input type="text"/>
C sigma(z)	<input type="text"/>
D sigma(z)	<input type="text"/>

Force F_z

A sigma(z)	<input type="text"/>
B sigma(z)	<input type="text"/>
C sigma(z)	<input type="text"/>
D sigma(z)	<input type="text"/>

Force F_y

A shear(z)	<input type="text"/>
B shear(z)	<input type="text"/>
C shear(z)	<input type="text"/>
D shear(z)	<input type="text"/>

Moment M_y

A sigma(z)	<input type="text"/>
B sigma(z)	<input type="text"/>
C sigma(z)	<input type="text"/>
D sigma(z)	<input type="text"/>

Moment M_z

A shear(z)	<input type="text"/>
B shear(z)	<input type="text"/>
C shear(z)	<input type="text"/>
D shear(z)	<input type="text"/>

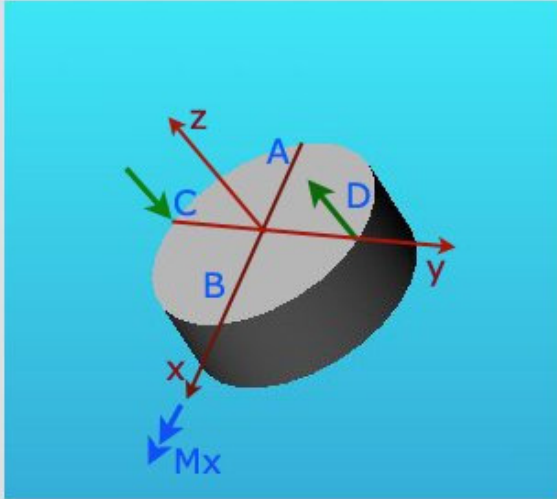
Area Properties

t = Thickness at axis CD

Calculate Q and I about axis CD

Combined Loading – Queries that Lead User to Solution

Circular Cross Section



Components of r:

Components of F:
 Fx Fy Fz

Shaft Radius: Inner Outer

For bending due to M_x , which is the neutral axis?
 AB CD

Zero stress at: A B C D
 Correct

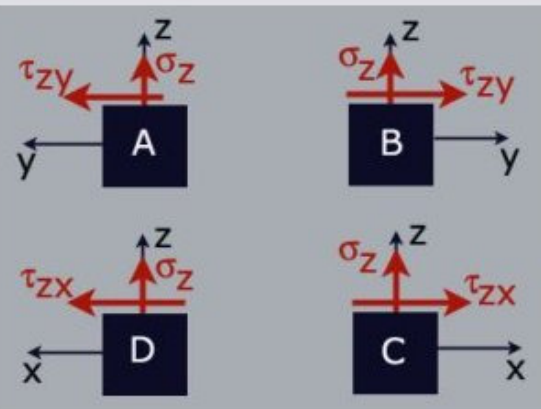
Components of Moment at cut:
 Mx My Mz

Fx - Shear Fy - Shear Fz - Axial
 Mx - Bending My - bending Mz - Torsion

Mx Bending : Normal Stress
 Enter magnitude of stress: Correct

Q I t J Area

Circular Cross Section - Stress at points



Force Fx	Moment Mx	Force Fz
A shear(zy) <input type="text" value="0.000e+000"/>	A sigma(z) <input type="text" value="0.000e+000"/>	A sigma(z) <input type="text"/>
B shear(zy) <input type="text" value="0.000e+000"/>	B sigma(z) <input type="text" value="0.000e+000"/>	B sigma(z) <input type="text"/>
C shear(zx) <input type="text" value="9.431e+001"/>	C sigma(z) <input type="text" value="-7.074e+002"/>	C sigma(z) <input type="text"/>
D shear(zx) <input type="text" value="9.431e+001"/>	D sigma(z) <input type="text" value="7.074e+002"/>	D sigma(z) <input type="text"/>

Force Fy	Moment My	Moment Mz
A shear(zy) <input type="text"/>	A sigma(z) <input type="text"/>	A shear(zy) <input type="text"/>
B shear(zy) <input type="text"/>	B sigma(z) <input type="text"/>	B shear(zy) <input type="text"/>
C shear(zx) <input type="text"/>	C sigma(z) <input type="text"/>	C shear(zx) <input type="text"/>
D shear(zx) <input type="text"/>	D sigma(z) <input type="text"/>	D shear(zx) <input type="text"/>

Area Properties

D = Distance of C or D from axis AB

Combined Loading – Help

circ_help.pdf - Adobe Reader

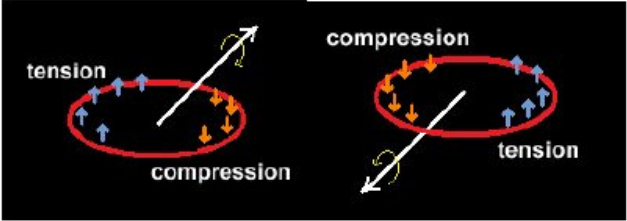
File Edit View Window Help

1 / 1 100%

Tools Sign Comment

Stresses in a Shaft with Circular Cross-section

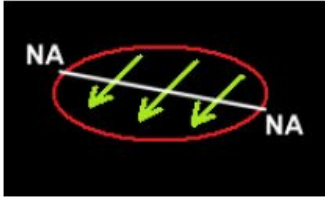
Bending



Normal stress (σ) has the largest magnitude at the end points of the diameter perpendicular to the moment vector.

$$r = \text{radius} \quad M = \text{bending moment} \quad I = \frac{\pi}{4} r^4 \quad \sigma = \frac{Mr}{I}$$

Shear



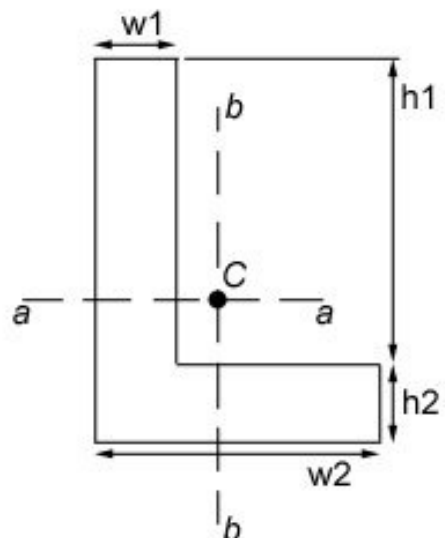
Shear stress (τ) has the largest magnitude at the diameter perpendicular to the force vector.

$$r = \text{radius} \quad V = \text{shear force} \quad Q = \frac{2}{3} r^3 \quad t = 2r \quad I = \frac{\pi}{4} r^4 \quad \tau = \frac{VQ}{It}$$

Axial

Section Properties, L-, T-, C-, I-Sections

L Beam



W1=

W2=

H1=

H2=

Calculate

reset

I_{aa}=

I_{bb}=

I_{ab}=

I_{min}=

Q_{aa}=

Q_{bb}=

Area=

aa Bending

D1= D2=

bb Bending

D1= D2=

HELP