

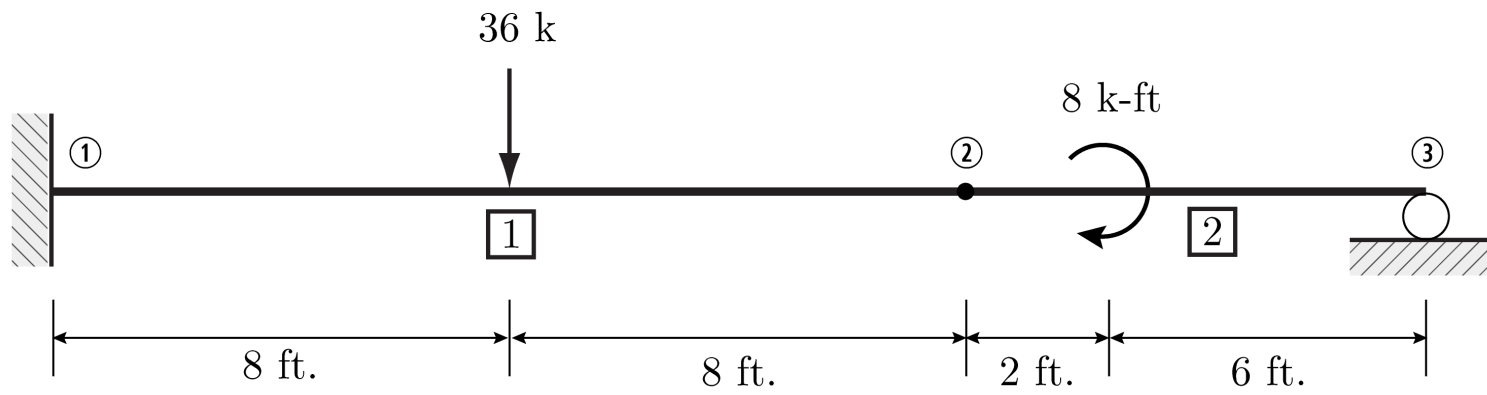
Beam with Member Loads Analysis Walkthrough Using SAP2000



CE 525 – Advanced Structural Analysis

North Carolina State University

Beam Example



$E = 4000 \text{ ksi}; I = 1500 \text{ in.}^4$ for all members

Define grid lines

SAP2000 v19.0.0 Educational 32-bit - (Untitled)

File Edit View Define Draw Select Assign Analyze Display Design Options Tools Help

3-d xy xz yz nv

X-Z Plane @ Y=0

X-Z Plane @ Y=0

X289.55 Y0. Z-90.2 GLOBAL Kip, in. F

Type here to search

5:54 PM 10/25/2017

Define material properties

$E = 4000 \text{ ksi}$

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File Edit View Define Draw Select Assign Analyze Display Design Options Tools Help

X-Z Plane @ Y=0

Material Property Data

General Data

Material Name and Display Color: MAT

Material Type: Other

Material Notes: Modify/Show Notes...

Weight and Mass

Weight per Unit Volume: 2.836E-04

Mass per Unit Volume: 7.345E-07

Units

Kip, in, F

Isotropic Property Data

Modulus of Elasticity, E: 4000

Poisson, U: 0.3

Coefficient of Thermal Expansion, A: 6.500E-06

Shear Modulus, G: 11153.846

Switch To Advanced Property Display

OK Cancel

X-Z Plane @ Y=0

X-94.63 Y0. Z172.44 GLOBAL Kip, in, F

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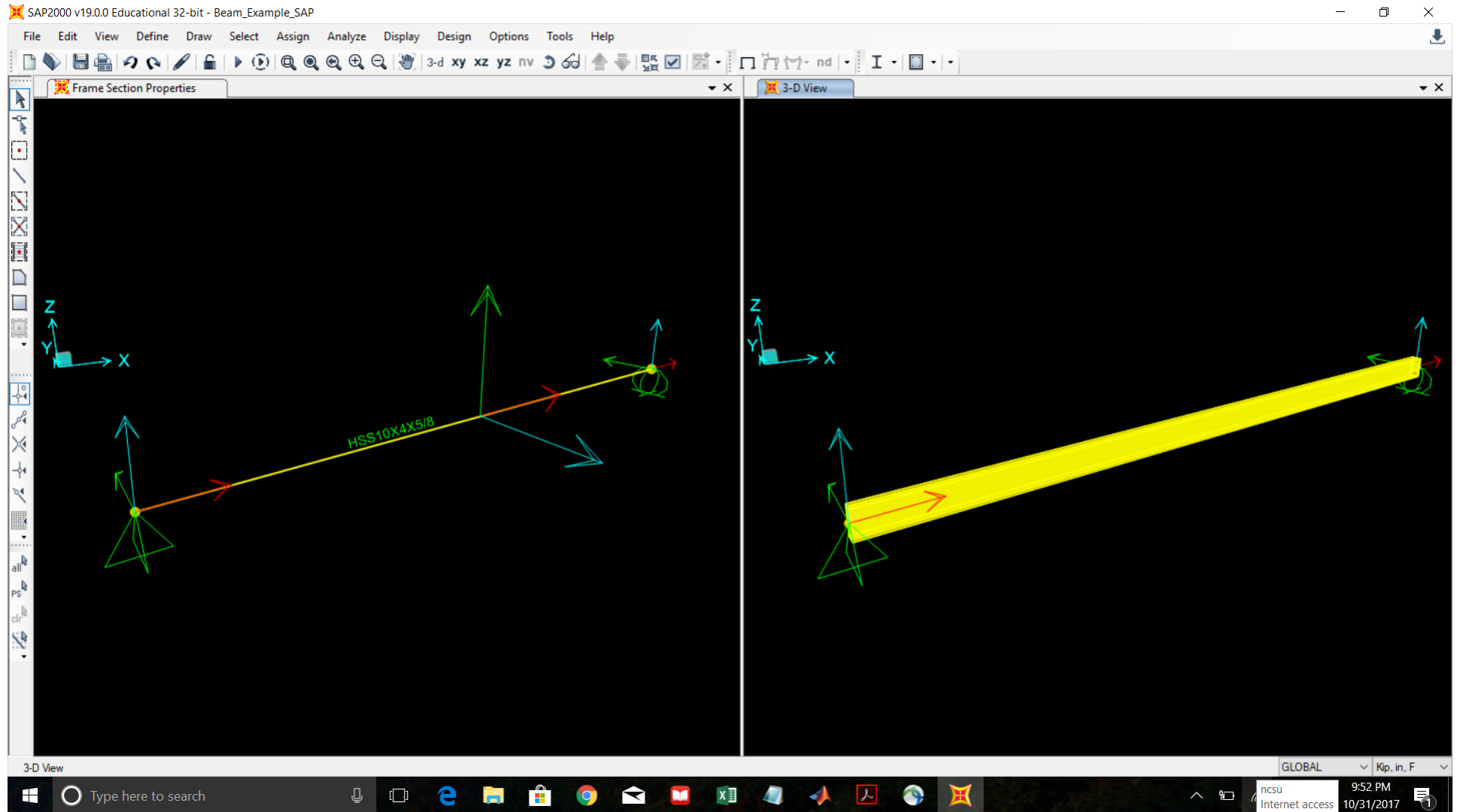
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SIDE NOTE: SAP Global Axis vs SAP Local Axis

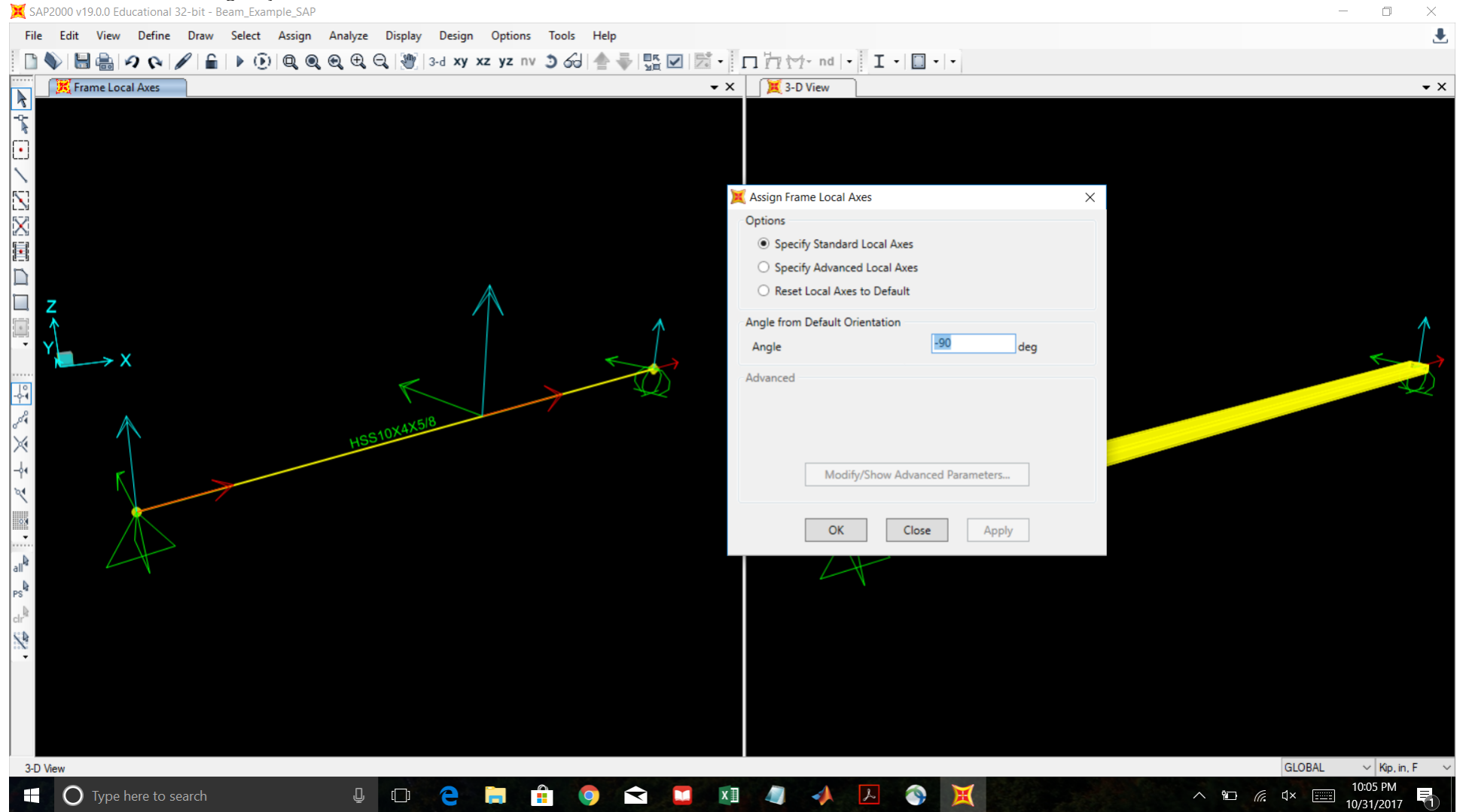
Every joint and frame object in SAP has its own local axis coordinate system (123/RGB).

As you can see in the HSS frame model below, the default **joint** local axes match the global axes, but the **frame** local axes do not.

(to see the extruded view on the right, go to "Display Options"->"General Options" Tab -> Select "Extrude" under "View Type")



You can manually change the direction of the default local axes for selected frames by going to "Assign"->"Frame"->"Local Axes".
You can do the same thing for joints.



Define section properties

$I = 1500 \text{ in}^4$

NOTE: moment of inertia is about the 3-axis

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File Edit View Define Draw Select Assign Analyze Display Design Options Tools Help

X-Z Plane @ Y=0

Frame Properties

Property Data

Section Name: FSEC1

Properties

Cross-section (axial) area	1.	Section modulus about 3 axis	1.
Moment of Inertia about 3 axis	1500	Section modulus about 2 axis	1.
Moment of Inertia about 2 axis	1.	Plastic modulus about 3 axis	1.
Product of Inertia about 2-3	0.	Plastic modulus about 2 axis	1.
Shear area in 2 direction	1.	Radius of Gyration about 3 axis	1.
Shear area in 3 direction	1.	Radius of Gyration about 2 axis	1.
Torsional constant	1.	Shear Center Eccentricity (x3)	0.

OK Cancel

X-Z Plane @ Y=0 X-74.31 Y0. Z172.44 GLOBAL Kip, in, F 5:55 PM 10/25/2017

Turn off shearing deformation in the 2 direction

SAP2000 v19.0.0 Educational 32-bit - Beam_Example_SAP

File Edit View Define Draw Select Assign Analyze Display Design Options Tools Help

X-Z Plane @ Y=0

General Section

Section Name: Frame Property/Stiffness Modification Factors

Section Notes:

Dimensions:

- Depth (t3):
- Width (t2):

Material: + MAT

Property/Stiffness Modifiers for Analysis:

Cross-section (axial) Area	1
Shear Area in 2 direction	0
Shear Area in 3 direction	1
Torsional Constant	1
Moment of Inertia about 2 axis	1
Moment of Inertia about 3 axis	1
Mass	1
Weight	1

X-54.37 Y0, Z145.34 GLOBAL Kip, in, F

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Make sure material property is correctly assigned


SAP2000 v19.0.0 Educational 32-bit - Beam_Example_SAP

File Edit View Define Draw Select Assign Analyze Display Design Options Tools Help

3-d xy xz yz nv

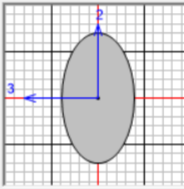
3-D View

General Section

Section Name: FSEC1 Display Color: 

Section Notes: [Modify/Show Notes...](#)

Dimensions

Depth (t3): 18. Section: 

Width (t2): 10.

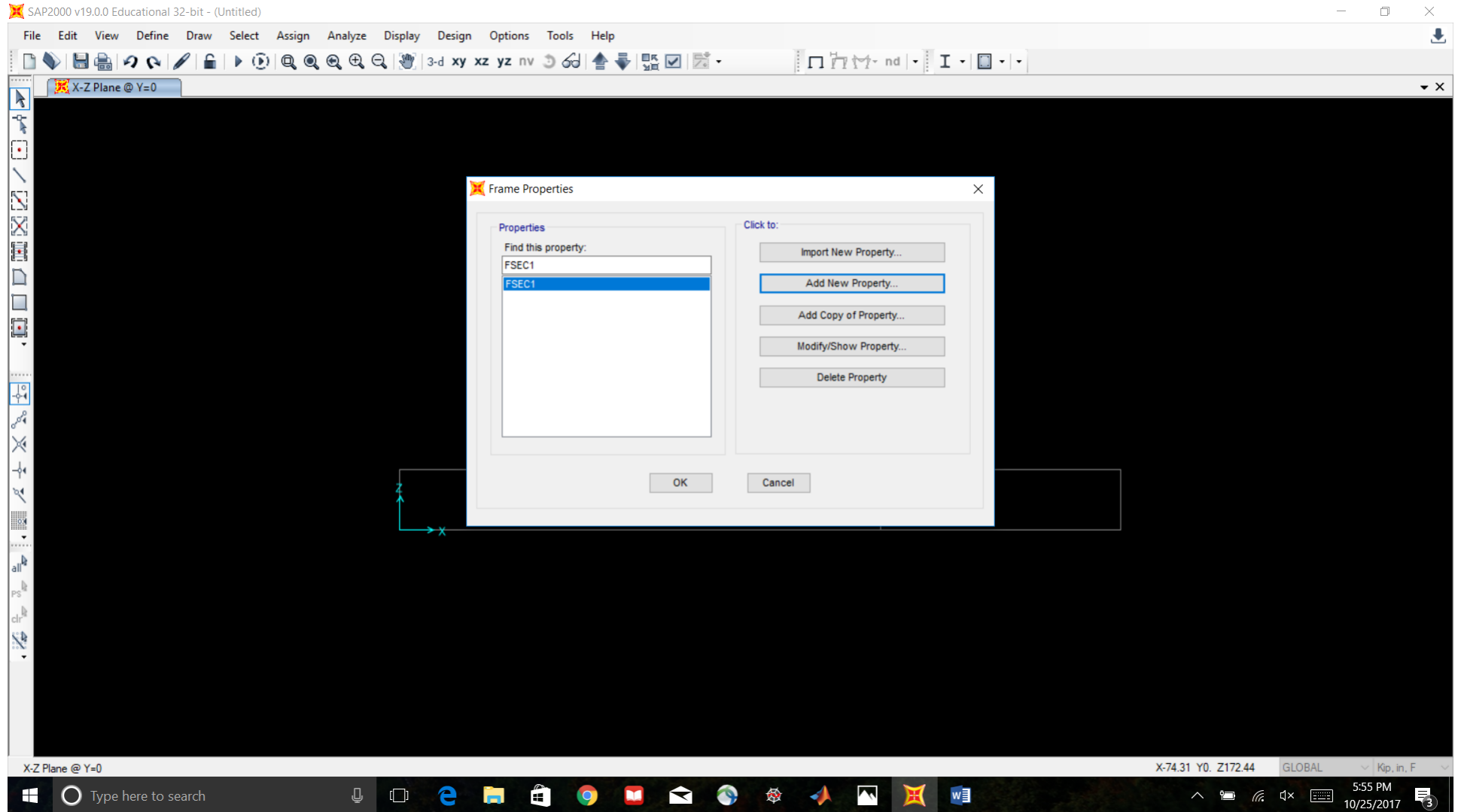
Material: + MAT Property Modifiers: [Set Modifiers...](#) Properties: [Section Properties...](#), [Time Dependent Properties...](#)

OK Cancel

3-D View GLOBAL Kip, in. F

Type here to search 6:04 PM 10/25/2017

Both members have the same section properties, so one defined frame section is adequate



Draw the members

SAP2000 v19.0.0 Educational 32-bit - (Untitled)

File Edit View Define Draw Select Assign Analyze Display Design Options Tools Help

3-d xy xz yz nv

X-Z Plane @ Y=0

Properties of Object	
Line Object Type	Straight Frame
Section	FSEC1
Moment Releases	Continuous
XY Plane Offset Normal	0.
Drawing Control Type	None <space bar>

X324.92 Y0. Z10.26 GLOBAL Kip, in. F

5:56 PM 10/25/2017

Assign joint restraints

SAP2000 v19.0.0 Educational 32-bit - (Untitled)

The screenshot displays the SAP2000 software interface. The main window shows a structural model with a horizontal beam and a vertical column. A dialog box titled "Assign Joint Restraints" is open, allowing the user to define restraints for a selected joint. The dialog box contains the following options:

- Restraints in Joint Local Directions:**
 - Translation 1
 - Translation 2
 - Translation 3
 - Rotation about 1
 - Rotation about 2
 - Rotation about 3
- Fast Restraints:** Four icons representing different restraint types: a fixed support, a roller support, a pinned support, and a joint.

Buttons at the bottom of the dialog box include "OK", "Close", and "Apply". The background shows a 3D coordinate system with X, Y, and Z axes. The status bar at the bottom indicates the current view is "X-Z Plane @ Y=0" and provides coordinates (X146.57 Y0. Z110.73) and units (GLOBAL, Kip, in, F). The Windows taskbar at the bottom shows the time as 5:57 PM on 10/25/2017.

Assign concentrated load of 36 lbs in the -Z direction at the midpoint of Member 1

You may use relative or absolute distance to specify the location of the load

SAP2000 v19.0.0 Educational 32-bit - (Untitled)

File Edit View Define Draw Select Assign Analyze Display Design Options Tools Help

3-d xy xz yz nv

Frame Concentrated Loads (DEAD)

Assign Frame Point Loads

General

Load Pattern: DEAD

Coordinate System: GLOBAL

Load Direction: Z

Load Type: Force

Options

Add to Existing Loads

Replace Existing Loads

Delete Existing Loads


Point Loads

	1.	2.	3.	4.
Absolute Distance	96	0	0	0
Loads	-36	0	0	0

Relative Distance from End-I Absolute Distance from End-I

Reset Form to Default Values

OK Close Apply



X-Z Plane @ Y=0

GLOBAL Kip, in, F

5:59 PM 10/25/2017

Assign concentrated moment of 8 k*ft (watch units) in +Y direction (remember right hand rule) at 2ft from the left end of Member 2

SAP2000 v19.0.0 Educational 32-bit - (Untitled)

The screenshot displays the SAP2000 software interface. The main window shows a 3D model of a frame structure with two members, labeled 1 and 2. A coordinate system is visible with X, Y, and Z axes. The 'Assign Frame Point Loads' dialog box is open, showing the following settings:

- Load Pattern: DEAD
- Coordinate System: GLOBAL
- Load Direction: Y
- Load Type: Moment
- Options: Replace Existing Loads
- Point Loads table:

	1.	2.	3.	4.	
Absolute Distance	24	0	0	0	in
Loads	96	0	0	0	kip-in
- Relative Distance from End-I:
 Absolute Distance from End-I:

The dialog box also includes a 'Reset Form to Default Values' button and 'OK', 'Close', and 'Apply' buttons. The status bar at the bottom indicates 'X-Z Plane @ Y=0', 'GLOBAL', and 'Kip, in, F'. The system tray shows the time as 6:00 PM on 10/25/2017.

SIDE NOTE: How to check assigned loads

See the loads assigned to any model object in SAP. Right click on the object ->go to “Loads” tab

You can change the assigned loads from this menu by double clicking on any fields below “Load Pattern”.

SAP2000 v19.2.1 Ultimate 64-bit - Beam_Example_SAP

File Edit View Define Draw Select Assign Analyze Display Design Options Tools Help

X-Z Plane @ Y=0

Object Model - Line Information

Location Assignments Loads Design

Identification

Label 1 Design Procedure None

Load Pattern	DEAD
Point Force	GLOBAL
Coordinate System	Z
Load Direction	-36. at 96. -36. at 96.

Assign Load...

Kip, in, F

Reset All

Update Display

Modify Display

OK

Cancel

Double click white background cell to edit item.

X-Z Plane @ Y=0 X69.87 Y0. Z-0.09 GLOBAL Kip, in, F

Type here to search

12:30 PM 11/5/2017

Turn off self-weight

SAP2000 v19.0.0 Educational 32-bit - (Untitled)

Define Load Patterns

Load Pattern Name	Type	Self Weight Multiplier	Auto Lateral Load Pattern
DEAD	Dead	0	
DEAD	Dead	0	

Click To:

- Add New Load Pattern
- Modify Load Pattern
- Modify Lateral Load Pattern...
- Delete Load Pattern
- Show Load Pattern Notes...
- OK
- Cancel

X-Z Plane @ Y=0

Set available DOFs for UZ and RY directions

SAP2000 v19.0.0 Educational 32-bit - (Untitled)

File Edit View Define Draw Select Assign Analyze Display Design Options Tools Help

3-d xy xz yz nv

Frame Concentrated Moments (DEAD)

Analysis Options

Available DOFs

UX UY UZ RX RY RZ

Fast DOFs

Space Frame Plane Frame Plane Grid Space Truss

XZ Plane XY Plane


OK
Cancel
Solver Options...

Tabular File

Automatically save XML, Excel or Microsoft Access tabular file after analysis

File name: _____

Database Tables Named Set: _____ Group: _____



X-Z Plane @ Y=0

GLOBAL Kip, in. F

6:01 PM 10/25/2017

Run the analysis

SAP2000 v19.0.0 Educational 32-bit - (Untitled)

File Edit View Define Draw Select Assign Analyze Display Design Options Tools Help

Set Load Cases to Run

Case Name	Type	Status	Action
DEAD	Linear Static	Not Run	Run
MODAL	Modal	Not Run	Do Not Run

Click to:

Run/Do Not Run Case

Show Case...

Delete Results for Case

Run/Do Not Run All

Delete All Results

Show Load Case Tree...

Analysis Monitor Options

Always Show

Never Show

Show After seconds

Model-Alive

Run Now

OK Cancel

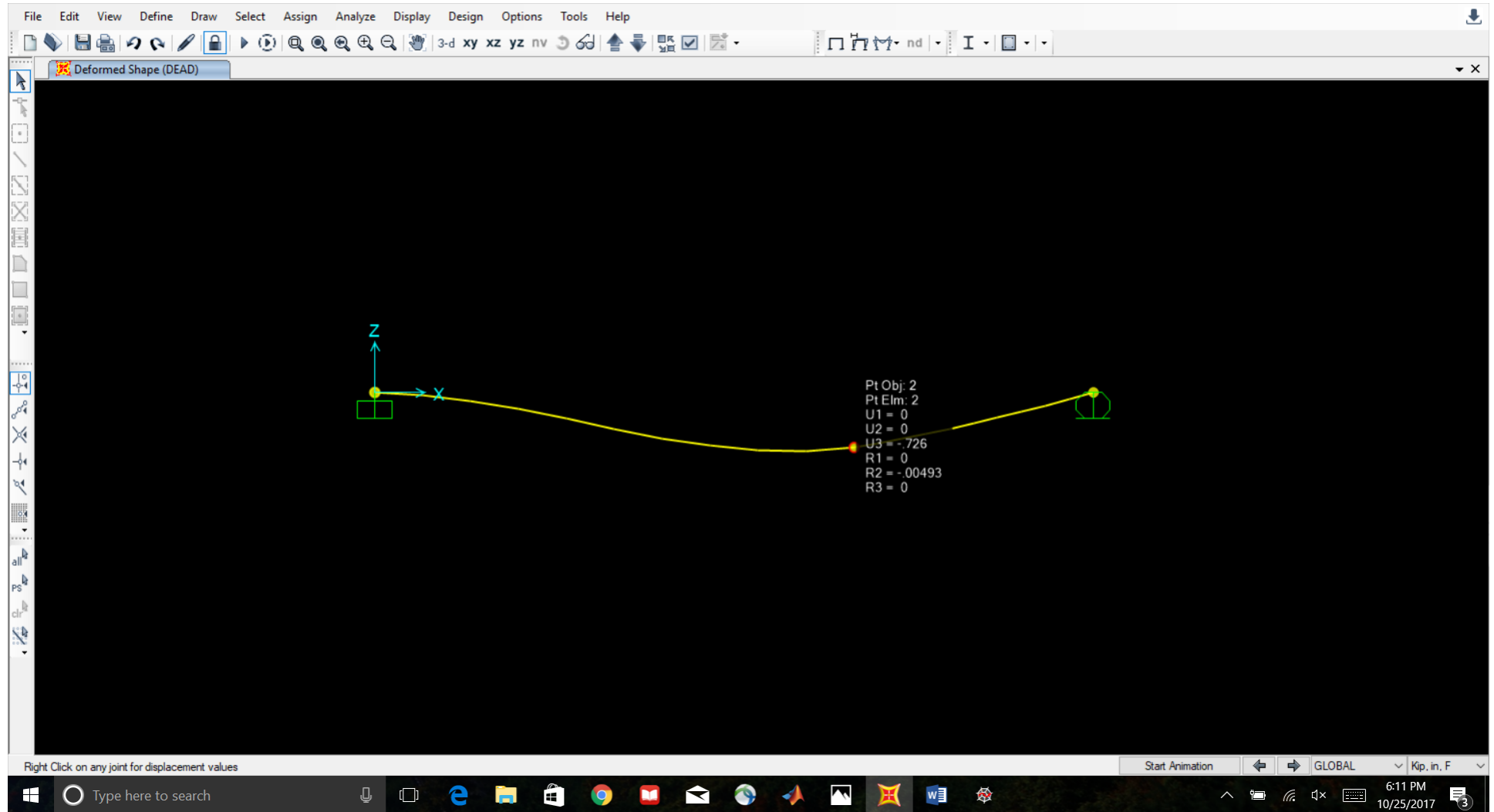
X-Z Plane @ Y=0

GLOBAL Kip, in, F

6:02 PM 10/25/2017

Deformed Shape

SAP2000 v19.0.0 Educational 32-bit - Beam_Example_SAP



Display shear diagram

Check “Shear 2-2” and “Show Values”

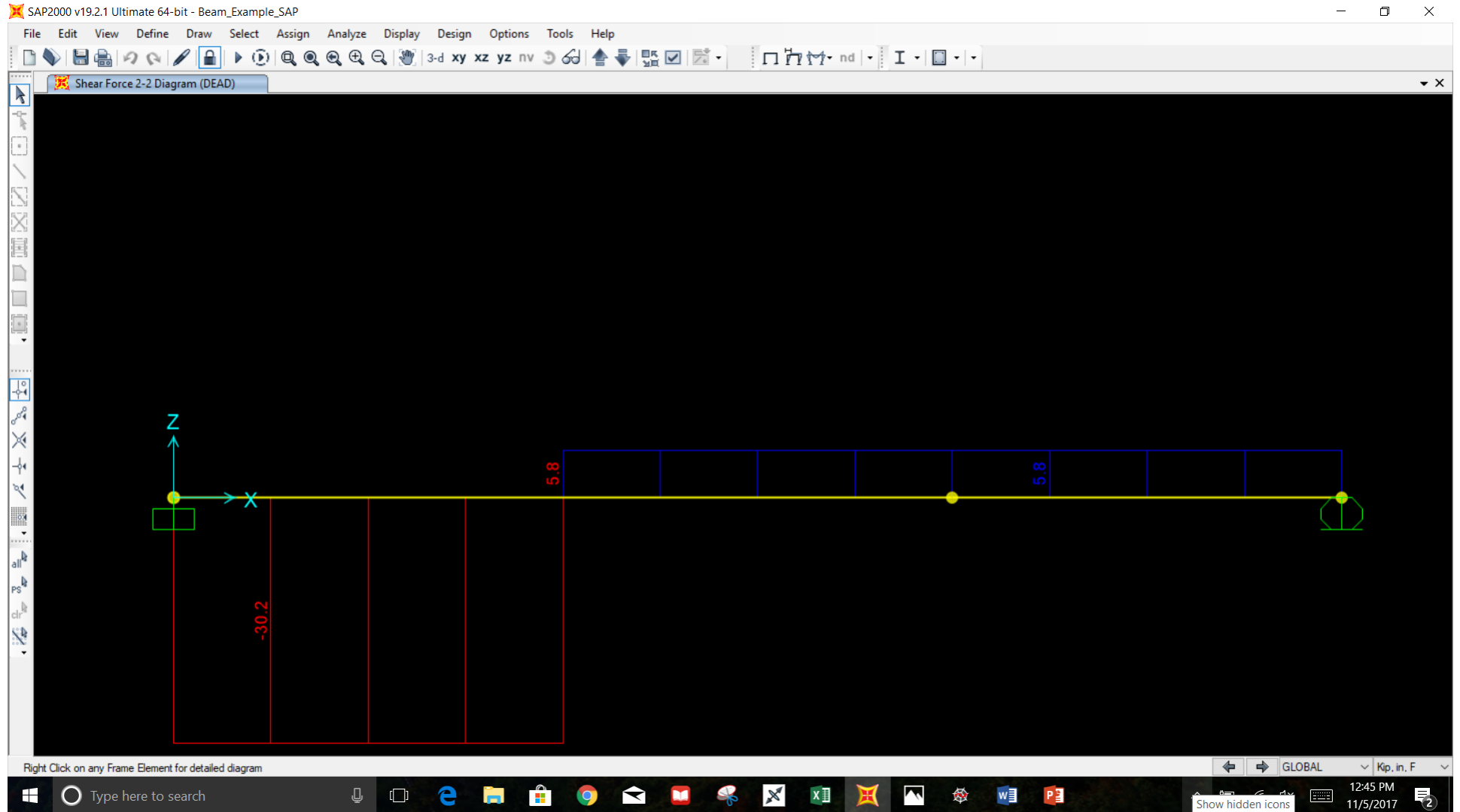
NOTE: You can change the scaling of the diagram using the “Scaling for Diagram”, “User Defined” field

The screenshot displays the SAP2000 v19.2.1 Ultimate 64-bit - Beam_Example_SAP interface. The main window shows a 3D view of a beam with a yellow shear diagram. A coordinate system is visible with Z pointing up and X pointing right. A dialog box titled "Display Frame Forces/Stresses" is open, showing the following settings:

- Case/Combo: DEAD
- Multivalued Options: Step (1)
- Display Type: Force
- Component: Shear 2-2
- Scaling for Diagram: User Defined (2)
- Options for Diagram: Show Values

The dialog box also includes buttons for "Reset Form to Default Values", "Reset Form to Current Window Settings", "OK", "Close", and "Apply". The Windows taskbar at the bottom shows the time as 12:43 PM on 11/5/2017.

Shear Diagram



Display moment diagram

Select "Moment 3-3" and "Show Values"

SAP2000 v19.2.1 Ultimate 64-bit - Beam_Example_SAP

The screenshot shows the SAP2000 software interface. The main window displays a beam model with a yellow moment diagram. A dialog box titled "Display Frame Forces/Stresses" is open, showing the following settings:

- Case/Combo: DEAD
- Multivalued Options: Step (1)
- Display Type: Force
- Component: Moment 3-3
- Scaling for Diagram: User Defined (0.05)
- Options for Diagram: Show Values

Buttons at the bottom of the dialog include "Reset Form to Default Values", "Reset Form to Current Window Settings", "OK", "Close", and "Apply".

Right Click on any joint for displacement values

Start Animation GLOBAL Kip, in, F

12:46 PM 11/5/2017

NOTE: To display positive moment on the compression side of the beam, go to “Options”->Deselect “Moment Diagrams on Tension Side”

SAP2000 v19.2.1 Ultimate 64-bit - BEAM_E~1

The screenshot displays the SAP2000 software interface. The main window shows a 3D view of a beam element with a moment diagram. The diagram is a blue line on a black background, showing a linear increase in moment from left to right. The left end of the beam is labeled with a moment of -1381. The right end is labeled with a moment of 461. A coordinate system is shown at the origin with X and Z axes. The 'Options' menu is open, and the 'Moment Diagrams on Tension Side' option is highlighted. The status bar at the bottom indicates 'Right Click on any Frame Element for detailed diagram' and 'GLOBAL Kip, in. F'. The Windows taskbar is visible at the bottom of the screen.

File Edit View Define Draw Select Assign Analyze Display Design Options Tools Help

- Dimensions/Tolerances...
- Colors
- Set Program Default Display Units... Ctrl+U
- Database
- Graphics Mode
- Set Calculator Memory...
- Auto Refresh
- Show Bounding Plane
- Moment Diagrams on Tension Side**
- Sound
- 3D View Up Direction
- Unlock Model
- Auto Save Model...
- Show Floating Property Window
- Show Result Values While Scrolling
- Show Tool Tips In Forms
- Save Model Settings...
- Customize Keyboard Shortcuts
- Reset Toolbars

Right Click on any Frame Element for detailed diagram

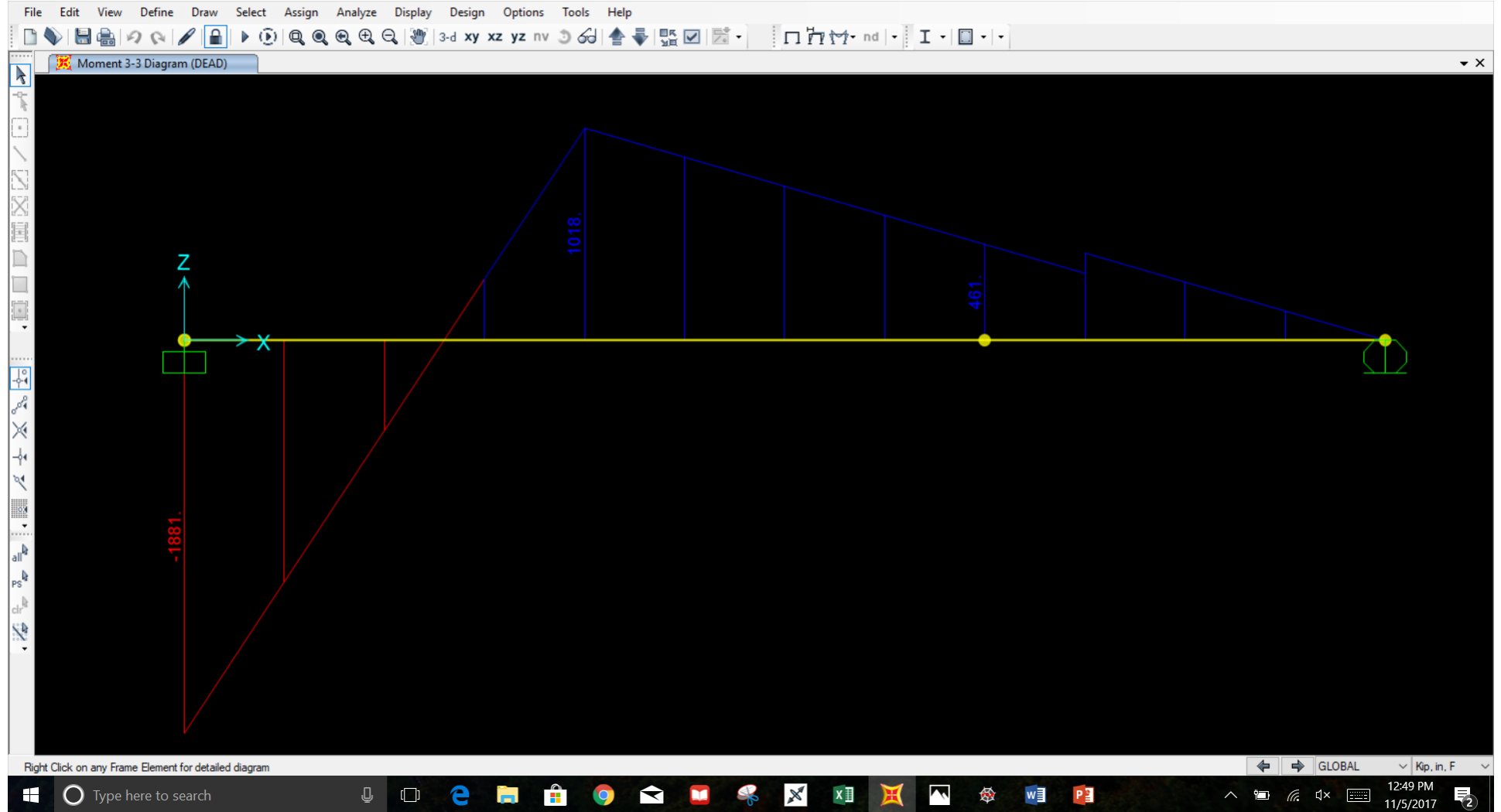
GLOBAL Kip, in. F

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Moment Diagram

SAP2000 v19.2.1 Ultimate 64-bit - Beam_Example_SAP



Display normal stresses (σ)

Select "Stress", "S11", and "Show Values"

NOTE: SAP will calculate bending and shear stresses for a generalized section based on geometric properties from the arbitrarily generated dimensions. In order to accurately calculate stresses for a given cross-section one needs to actually define the specific geometry when creating the frame section.

The screenshot displays the SAP2000 v19.0.0 Educational 32-bit - Beam_Example_SAP interface. The main window shows a 3D model of a beam in the X-Z plane, with a coordinate system (X, Y, Z) and a green rectangular cross-section. The 'Display Frame Forces/Stresses' dialog box is open, showing the following settings:

- Case/Combo: DEAD
- Multivalued Options: Step (1)
- Display Type: Stress
- Component: S11
- Stress Point: Stress Max
- Plot Type: Diagram
- Scaling for Diagram: Automatic
- Options for Diagram: Show Values

Buttons at the bottom of the dialog include 'Reset Form to Default Values', 'Reset Form to Current Window Settings', 'OK', 'Close', and 'Apply'.