

# Truss Example

## Walkthrough Using SAP2000

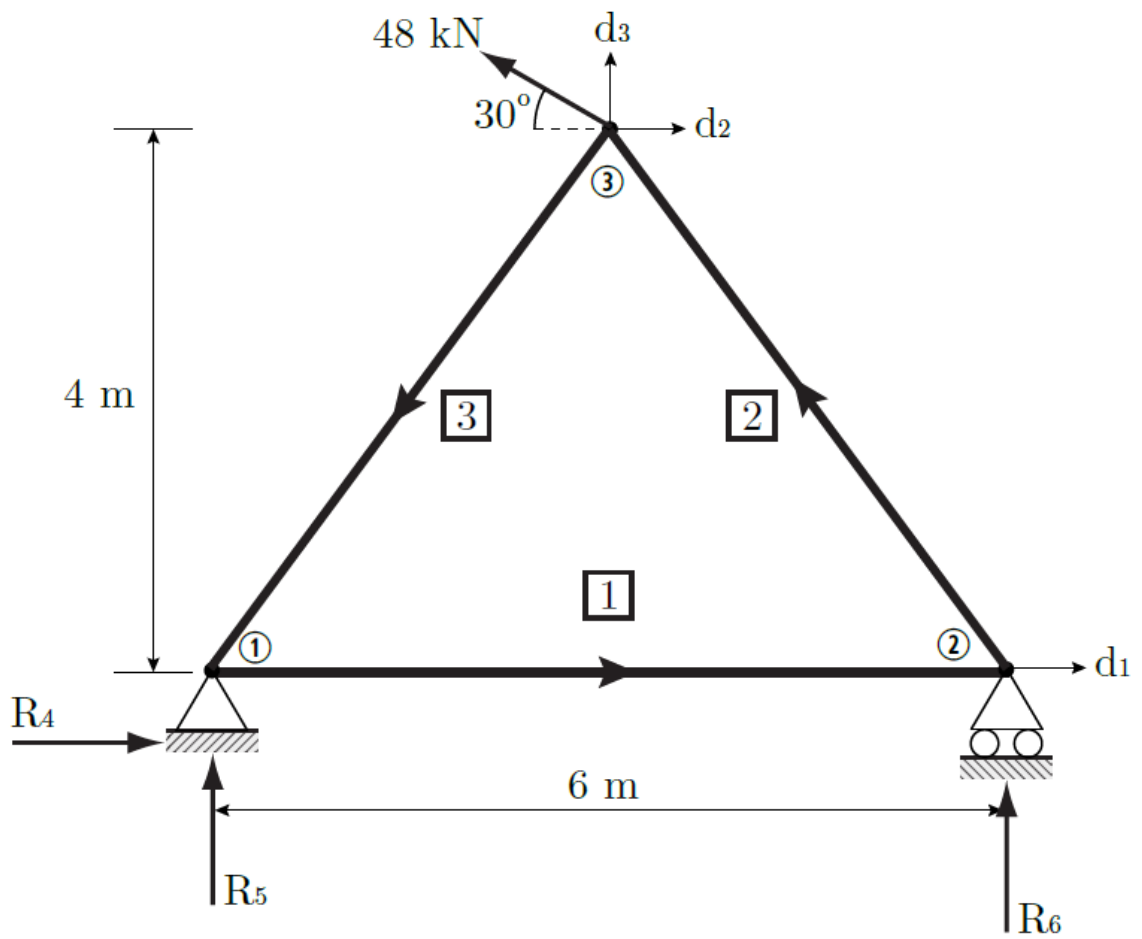


**CE 525 – Advanced Structural Analysis**

**North Carolina State University**



# Truss Example



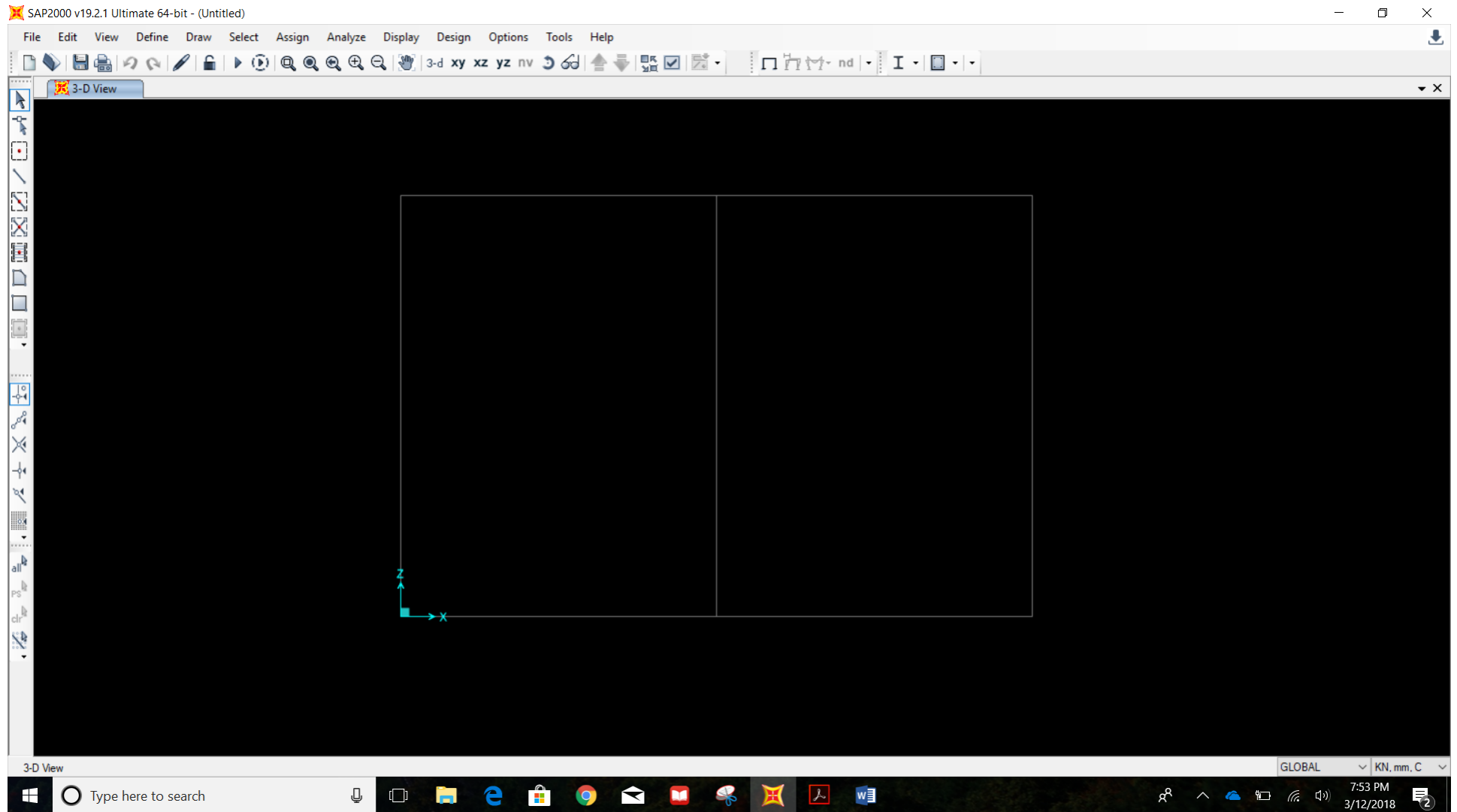
$E = 60 \text{ GPa}$  ;  $A = 2,000 \text{ mm}^2$  for all members

## Create New Model

NOTE: units in this tutorial are kN,mm

Set XZ View

Create Grid Lines



# Define material properties

E = 60 GPa

SAP2000 v19.2.1 Ultimate 64-bit - (Untitled)

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

3-D View

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: 7.697E-08

Mass per Unit Volume: 7.849E-12

**Units**

KN, mm, C

**Isotropic Property Data**

Modulus of Elasticity, E: 60

Poisson, U: 0.3

Coefficient of Thermal Expansion, A: 1.170E-05

Shear Modulus, G: 76.9031

Switch To Advanced Property Display

OK Cancel

3-D View GLOBAL KN, mm, C

Type here to search

7:56 PM 3/12/2018

## Define Section Properties

A = 2000 mm<sup>2</sup> for all members

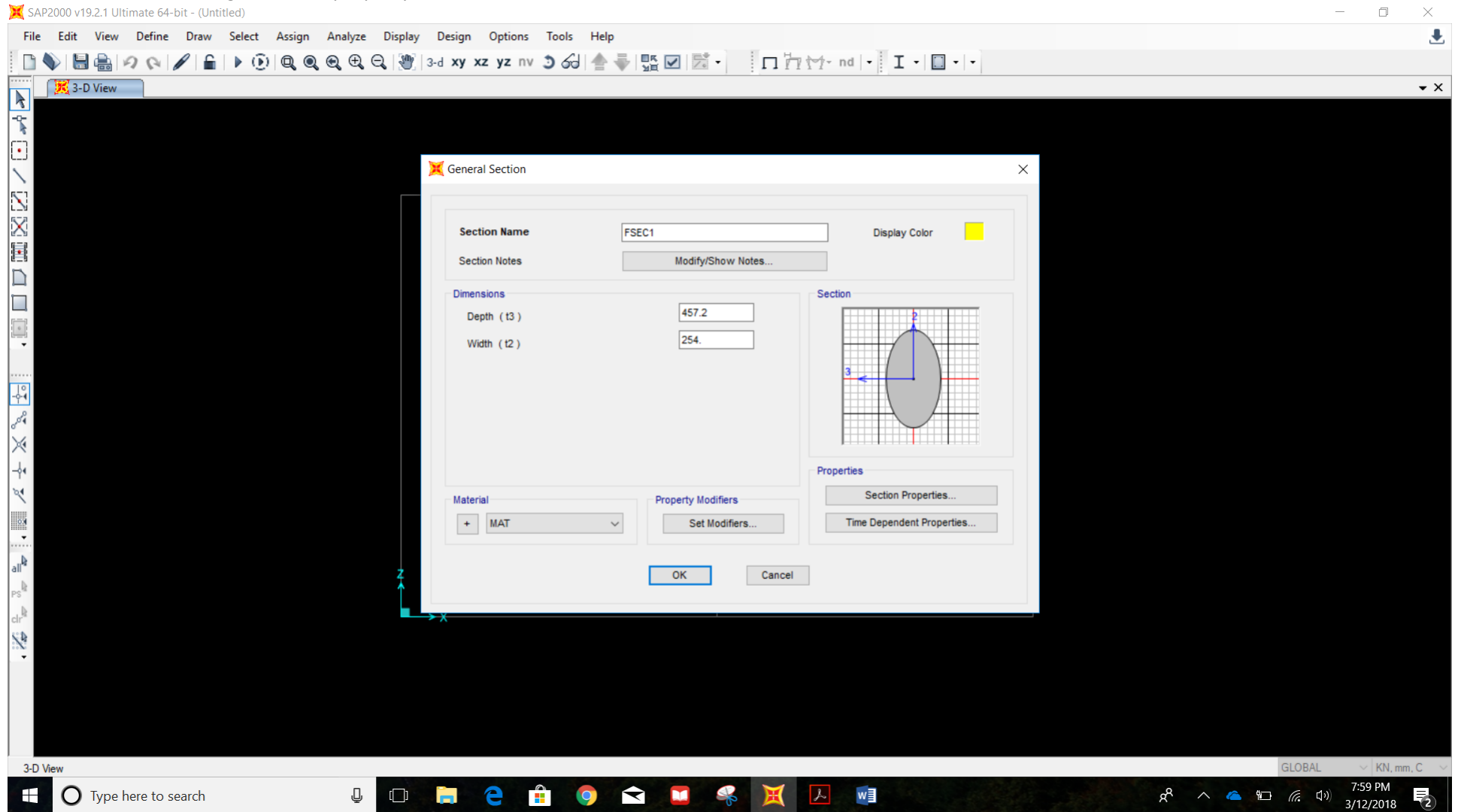
NOTE: defining more than one frame section is unnecessary

The screenshot displays the SAP2000 v19.2.1 Ultimate 64-bit interface. The main window is in '3-D View' mode. A 'Frame Properties' dialog box is open, and within it, the 'Property Data' dialog box is active. The 'Section Name' field is set to 'FSEC1'. The 'Properties' section contains the following fields:

Property	Value
Cross-section (axial) area	2000
Moment of Inertia about 3 axis	1.
Moment of Inertia about 2 axis	1.
Product of Inertia about 2-3	0.
Shear area in 2 direction	1.
Shear area in 3 direction	1.
Torsional constant	1.
Section modulus about 3 axis	1.
Section modulus about 2 axis	1.
Plastic modulus about 3 axis	1.
Plastic modulus about 2 axis	1.
Radius of Gyration about 3 axis	1.
Radius of Gyration about 2 axis	1.
Shear Center Eccentricity (x3)	0.

The 'OK' button is highlighted in blue. The background shows a 3D coordinate system with X, Y, and Z axes.

NOTE: remember to assign material property to frame section



## Draw the members

NOTE: Select "Pinned" under "Moment Releases". Now all drawn members will be connected by pinned joints.

SAP2000 v19.2.1 Ultimate 64-bit - (Untitled)

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

3-d xy xz yz nv

3-D View

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

3-D View GLOBAL KN, mm, C

8:03 PM 3/12/2018



### SIDE NOTE: Local Axes of Joints and Frames

Every joint and frame object in SAP has its own local axis coordinate system (123/RGB). View the default local frame and local joint axes of the truss by checking the appropriate boxes in the "Set Display Options" menu.

SAP2000 v19.2.1 Ultimate 64-bit - (Untitled)

The screenshot displays the SAP2000 software interface. The main window shows a 3-D View of a truss structure. The truss is composed of yellow members and is supported by a vertical green member. The local axes are shown as red, green, and blue arrows originating from the joints. A 'Set Display Options...' dialog box is open, showing the 'Display Options' window. The 'General Options' tab is selected, and the 'Local Axes' checkbox is checked for both Joints and Frames. The 'Apply to All Windows' checkbox is unchecked. The dialog box also includes buttons for 'Reset Form to Default Values', 'Reset Form to Current Window Settings', 'OK', 'Close', and 'Apply'.

3-D View

Set Display Options...

Display Options

Object Options General Options

Joints

- Labels
- Restraints
- Springs
- Local Axes
- Invisible
- Not in View

Frames

- Labels
- Sections
- Releases
- Local Axes
- Not in View

Cables

- Labels
- Sections
- Not in View

Tendons

- Labels
- Sections
- Local Axes
- Not in View

Areas

- Labels
- Sections
- Local Axes
- Not in View

Solids

- Labels
- Sections
- Local Axes
- Not in View

Links

- Labels
- Sections
- Local Axes
- Not in View

Apply to All Windows

Reset Form to Default Values

Reset Form to Current Window Settings

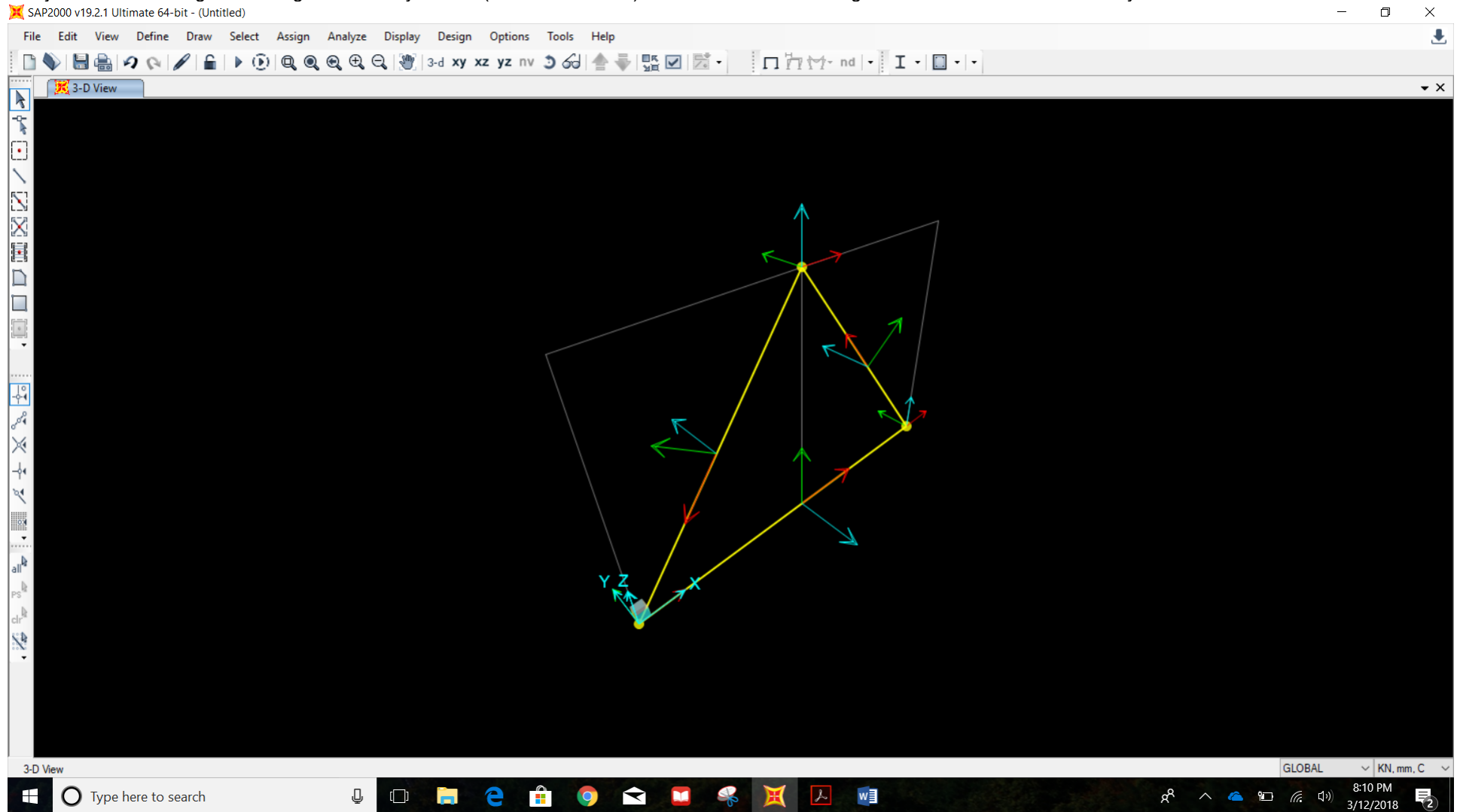
OK Close Apply

3-D View GLOBAL KN, mm, C

Type here to search

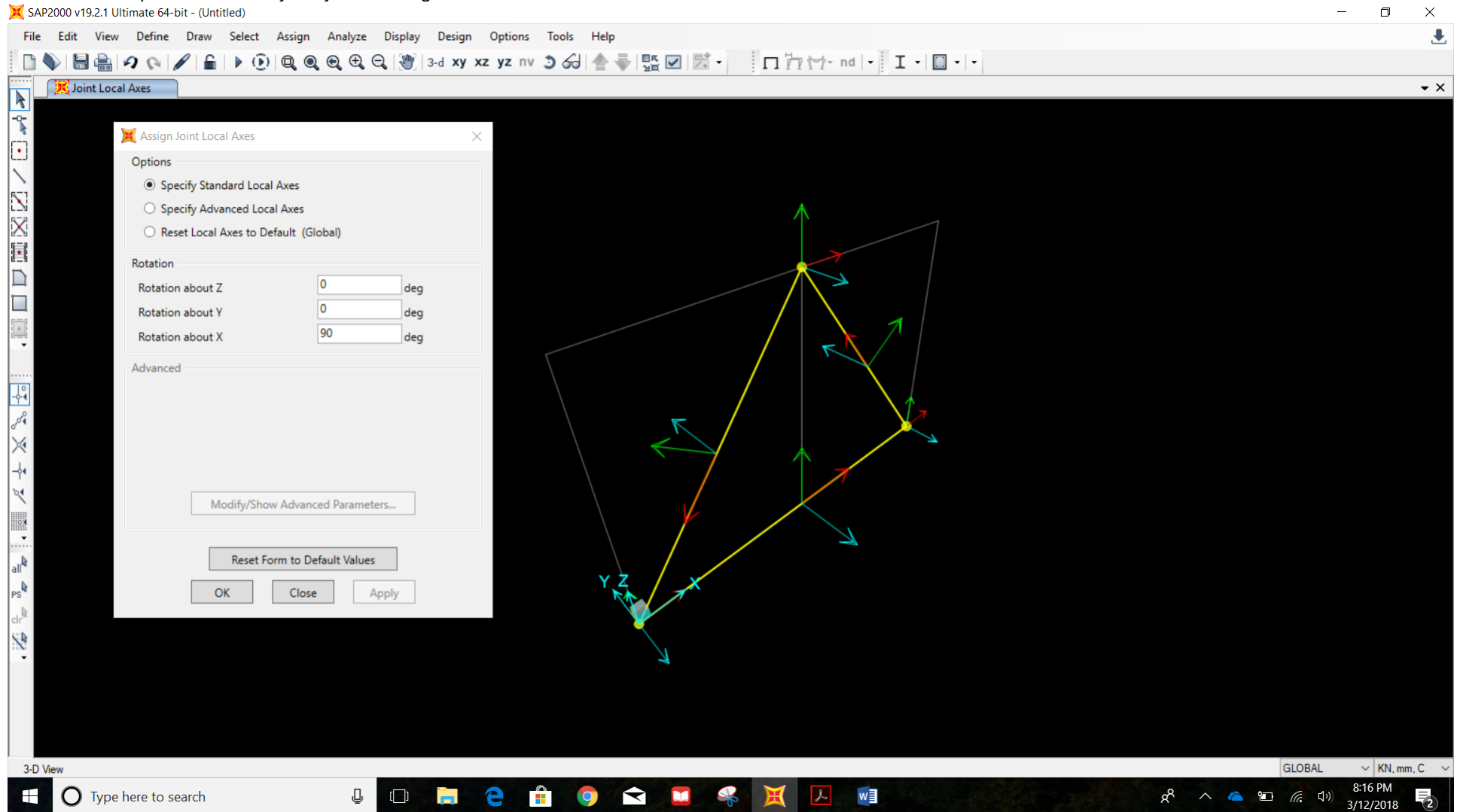
8:09 PM 3/12/2018

The joint local axes align with the global axes by default (123/RGB -> XYZ). The frame local axes align with the direction in which they are drawn.



You can manually change the direction of the default local axes for selected joints by going to "Assign"->"Joints"->"Local Axes". The three joints have been rotated by 90 degrees about the global X-axis. This joint orientation matches the convention used in class.

The default local axes of the frame elements can also be changed if necessary (via "Assign"->"Frames"->"Local Axes"). The tutorial will proceed with only the joints having been rotated.



## Assign joint restraints

Pin at joint 1 ( $u_1, u_2$  fixed). Roller at joint 2 ( $u_2$  fixed)

NOTE: Restraints are defined according to joint local axes. Be careful how you define restraints if the joints are rotated out of the default orientation.

SAP2000 v19.2.1 Ultimate 64-bit - TRUSS\_EXAMPLE

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

3-d xy xz yz nv

Joint Restraints

Assign Joint Restraints

Restraints in Joint Local Directions

- Translation 1
- Translation 2
- Translation 3
- Rotation about 1
- Rotation about 2
- Rotation about 3

Fast Restraints

OK Close Apply

X-Z Plane @ Y=0

X6000. Y0. Z0. GLOBAL KN, mm, C

8:35 PM 3/12/2018

Assign concentrated joint load of  $-24\sqrt{3}$  kN in the global X-direction at the top joint.  
Assign concentrated joint load of +24 kN in the global Z-direction at the top joint

SAP2000 v19.2.1 Ultimate 64-bit - (Untitled)

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

3-d xy xz yz nv

### Assign Joint Forces

General

Load Pattern: DEAD

Coordinate System: GLOBAL

Forces

Force Global X	-41.5692	kN
Force Global Y	0	kN
Force Global Z	24	kN
Moment about Global X	0	kN-mm
Moment about Global Y	0	kN-mm
Moment about Global Z	0	kN-mm

Options

Add to Existing Loads

Replace Existing Loads

Delete Existing Loads

Reset Form to Default Values

OK Close Apply

X-Z Plane @ Y=0

GLOBAL KN, mm, C

8:26 PM 3/12/2018

**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 - (Untitled)

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

Joint Loads (DEAD)

Object Model - Point Information

Location Assignments Loads

Identification

Label 3

Load Pattern	DEAD
Joint Force	
Coordinate System	GLOBAL
Force in X Dir	-41.5692
Force in Z Dir	24

Assign Load...

KN, mm, C

Reset All

Update Display

Modify Display

OK

Cancel

Double click white background cell to edit item.

X-Z Plane @ Y=0

GLOBAL KN, mm, C

8:27 PM 3/12/2018

# Turn off self-weight

SAP2000 v19.2.1 Ultimate 64-bit - (Untitled)

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

3-d xy xz yz nv

Joint Loads (DEAD)

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

GLOBAL KN, mm, C

8:28 PM 3/12/2018

# Set available DOFs to UX and UZ directions

SAP2000 v19.2.1 Ultimate 64-bit - (Untitled)

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

3-d xy xz yz nv

Joint Loads (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

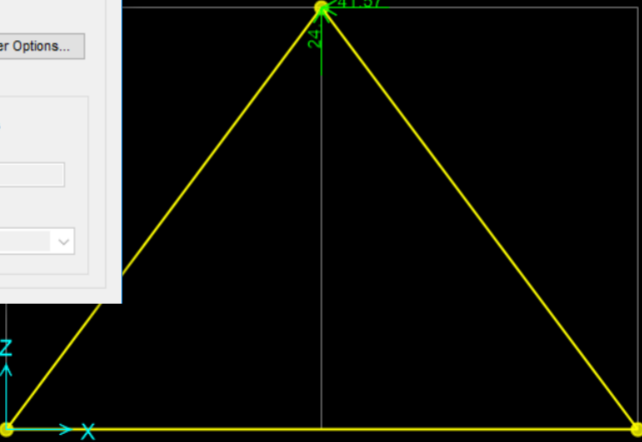
OK Cancel Solver Options...

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 KN, mm, C

8:29 PM 3/12/2018



# Run the analysis

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

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

Frame Co

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

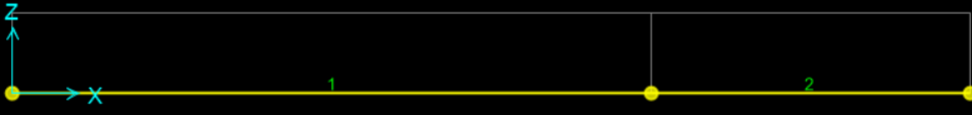
Never Show

Show After  seconds

Model-Alive

Run Now

OK Cancel



X-Z Plane @ Y=0

GLOBAL Kip, in, F

6:02 PM 10/25/2017

Observe deformed shape (click "Show Deformed Shape" icon in the ribbon)

Check tabulated displacements ("Display"->"Show Tables"->"Joint Output"->"Displacements"->OK)

The screenshot displays a software interface with two main windows. The left window, titled "Joint Displacements", contains a table with the following data:

Joint Text	OutputCase	CaseType Text	U1 mm	U2 mm	U3 mm	R1 Radians	R2 Radians	R3 Radians
1	DEAD	LinStatic	0	0	0	0	0	0
2	DEAD	LinStatic	-1.48923	0	0	0	0	0
3	DEAD	LinStatic	-3.150241	1.339711	0	0	0	0

The right window shows a 3D visualization of a triangular structure. The structure is rendered in yellow, with a coordinate system (X, Y, Z) visible at the bottom left. The structure consists of three vertices and three edges. The bottom-left vertex is at the origin (0,0,0). The bottom-right vertex is on the X-axis. The top vertex is in the YZ-plane. The structure is shown in a perspective view.

The Windows taskbar at the bottom shows the search bar, taskbar icons, and system tray with the date and time: 8:38 PM 3/12/2018.

## Post-Processing: Axial Bar Forces

Click "Show Forces/Stresses" Icon -> "Frames" -> "Axial Force"

Results can also be tabulated

The screenshot displays the SAP2000 software interface. The main window shows an Axial Force Diagram (DEAD) for a truss structure. The diagram features a yellow truss with a horizontal base and two inclined members meeting at a peak. The axial forces are shown as red lines along the members, with values such as -29.7, -91.64, and 49.64. A blue truss outline is also visible. The software interface includes a menu bar (File, Edit, View, Define, Draw, Select, Assign, Analyze, Display, Design, Options, Tools, Help) and a toolbar. 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: Axial Force
- Scaling for Diagram: Automatic
- Options for Diagram: Show Values

Buttons at the bottom of the dialog box include "Reset Form to Default Values", "Reset Form to Current Window Settings", "OK", "Close", and "Apply". The Windows taskbar at the bottom shows the system tray with the date and time: 8:44 PM, 3/12/2018.

## Post-Processing: Reactions

Click "Show Forces/Stresses" Icon ->"Joints"->"Display Joint Reactions"

Results can also be tabulated

The screenshot shows the SAP2000 v19.2.1 Ultimate 64-bit interface. The main window displays a truss structure with joint reactions. The reaction values are:

- Joint 1:  $F_1 = 41.57$ ,  $F_2 = 15.71$
- Joint 2:  $F_2 = -39.71$

The 'Display Joint Reactions' dialog box is open, showing the following settings:

- Case/Combo Name: DEAD
- Multivalued Options: Step (value: 1)
- Display Types: Tabulated

Buttons in the dialog include: Reset Form to Default Values, Reset Form to Current Window Settings, OK, Close, and Apply.