

# Truss Example

## Walkthrough Using SAP2000

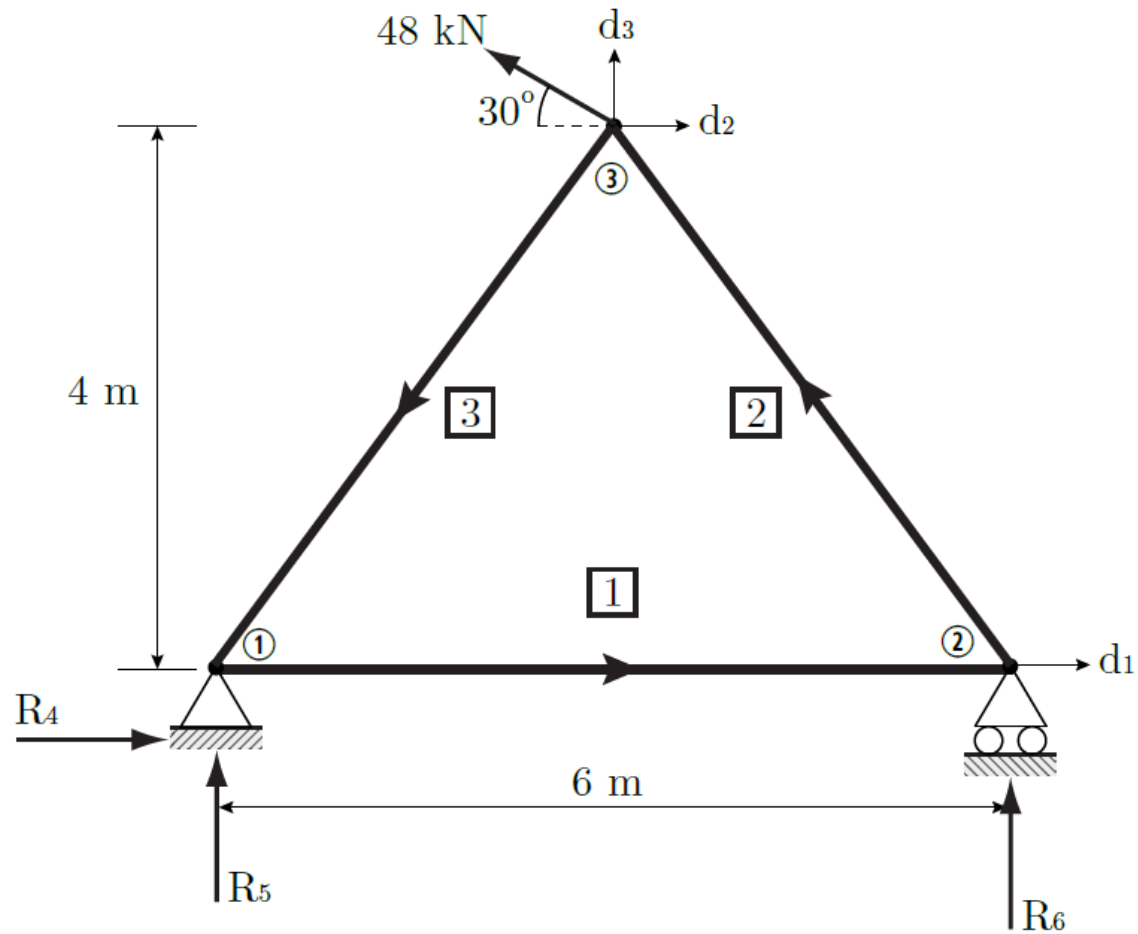


CE 325 – Structural Analysis I

North Carolina State University



# Truss Example



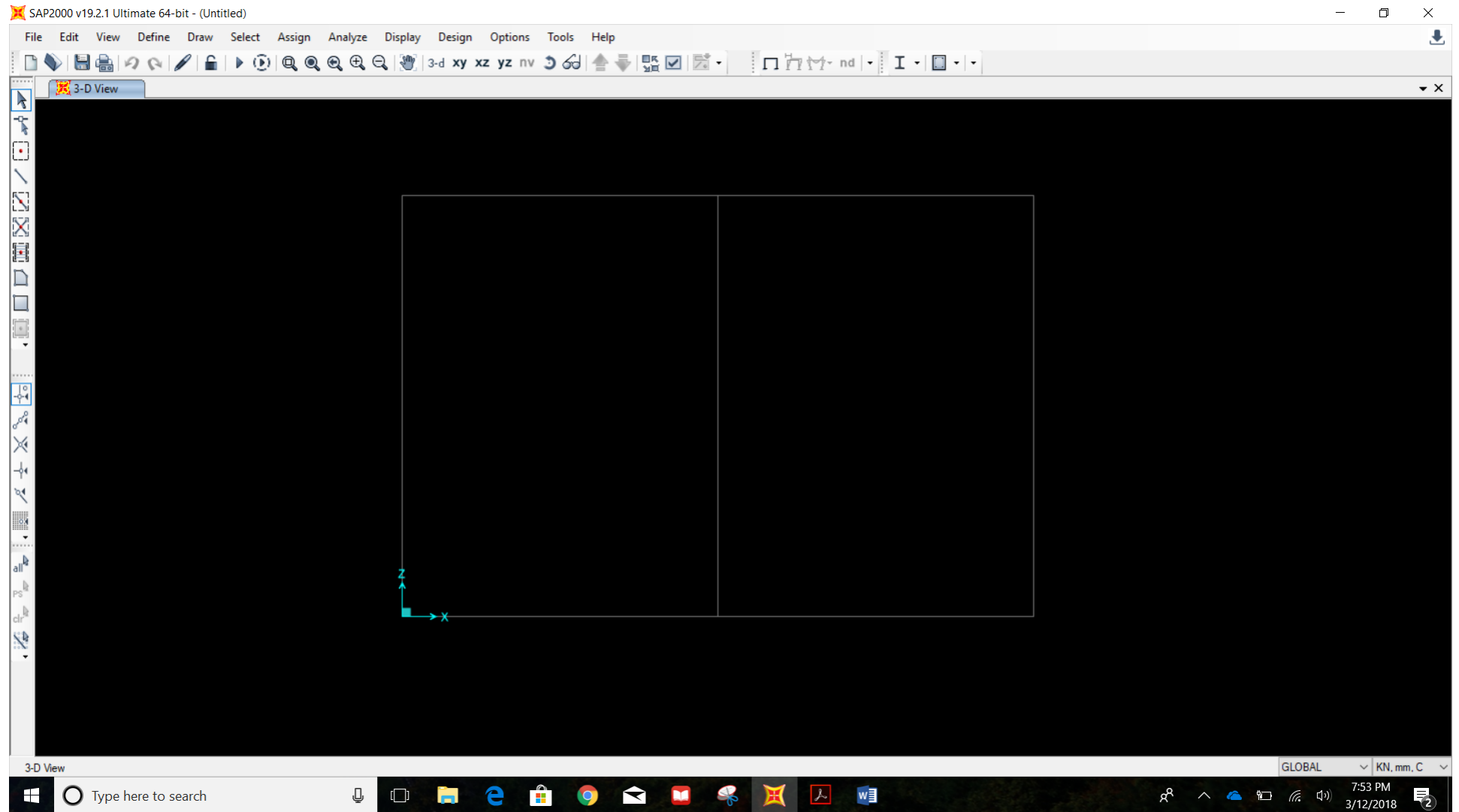
$E = 60 \text{ GPa}$  ;  $A = 2,000 \text{ mm}^2$  for all members

## 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

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

3-D View

Frame Properties

Property Data

Section Name: FSEC1

Properties

Cross-section (axial) area	2000	Section modulus about 3 axis	1.
Moment of Inertia about 3 axis	1.	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

3-D View GLOBAL KN, mm, C

Type here to search

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NOTE: remember to assign material property to frame section

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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: [Yellow]

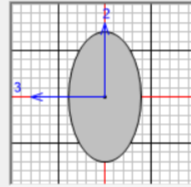
Section Notes: [Modify/Show Notes...]

Dimensions

Depth (t3): 457.2

Width (t2): 254.

Section



Properties

Material: [MAT]

Property Modifiers: [Set Modifiers...]

[Section Properties...]

[Time Dependent Properties...]

[OK] [Cancel]

3-D View GLOBAL KN, mm, C

Type here to search

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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 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

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### 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 a central vertical member. Local axes (123/RGB) are shown for the joints and frames. The 'Display Options' dialog box is open, showing settings for various object types. 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

Solids

- Labels
- Sections
- Local Axes
- Not in View

Links

- Labels
- Sections
- Local Axes
- Not in View

Areas

- Labels
- Sections
- Local Axes
- Not in View

Apply to All Windows

Reset Form to Default Values

Reset Form to Current Window Settings

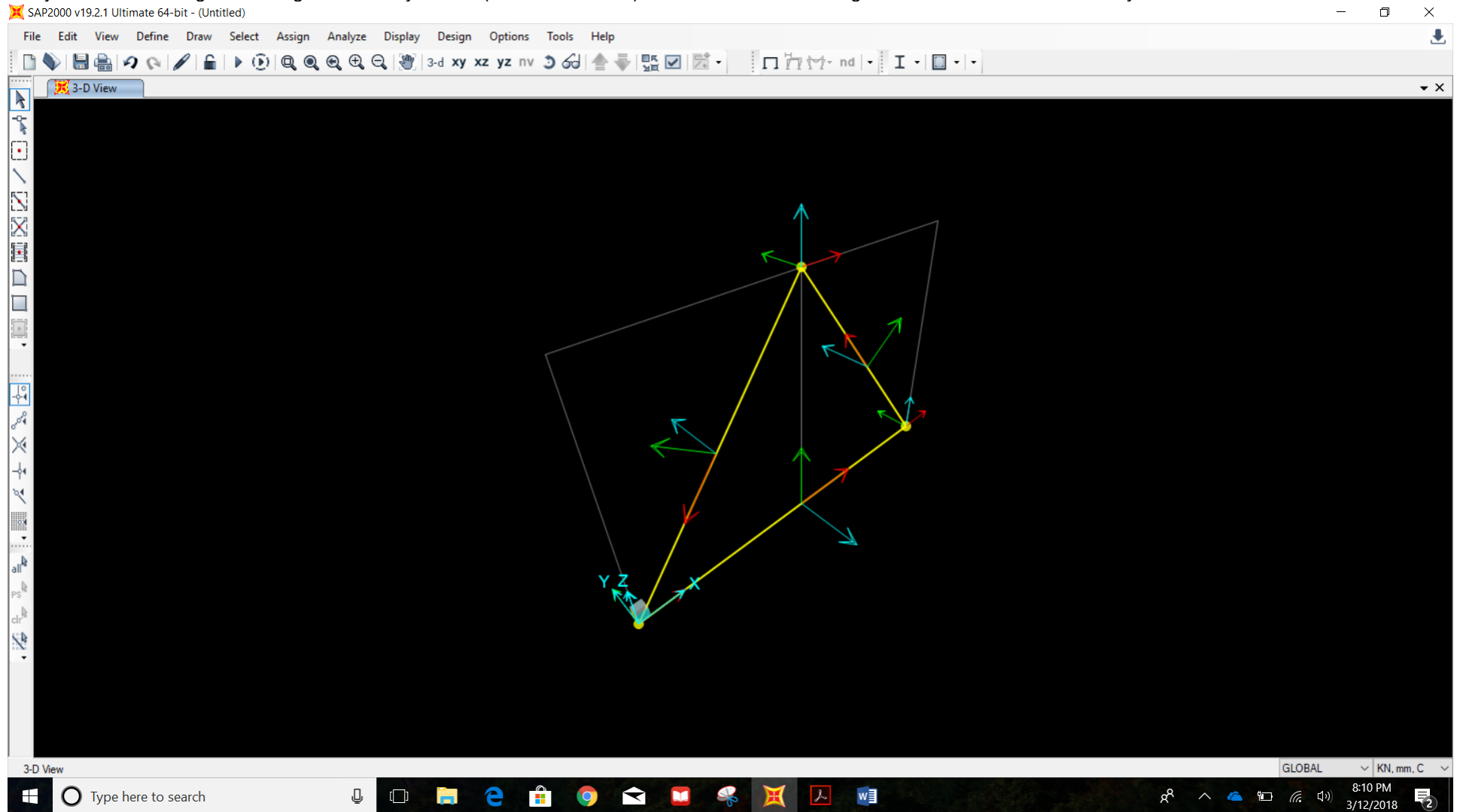
OK Close Apply

3-D View GLOBAL KN, mm, C

Type here to search

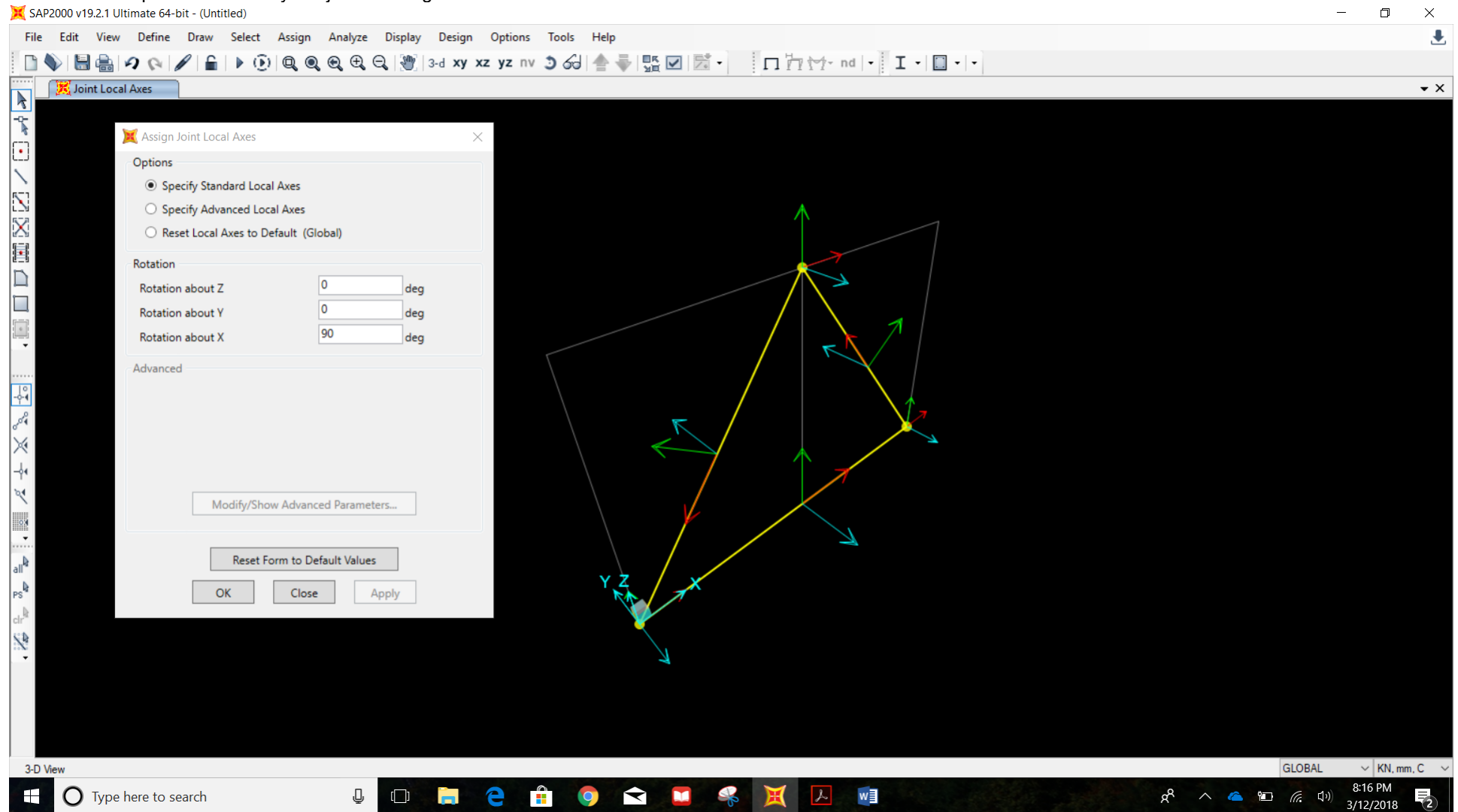
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The joint local axes align with the global axes by default (123/RGB -> XYZ). The frame local axes align with the direction in which they are drawn.



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

The screenshot displays the SAP2000 software interface. The main window shows a 3D truss model with yellow members and green arrows indicating local axes. A dialog box titled "Assign Joint Restraints" is open, showing the "Restraints in Joint Local Directions" section with the following options:

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

The "Fast Restraints" section contains four icons representing different restraint types: a fixed support, a roller support, a pin support, and a point support. The "OK", "Close", and "Apply" buttons are visible at the bottom of the dialog box. The status bar at the bottom of the software window shows "X-Z Plane @ Y=0", "X6000. Y0. Z0.", "GLOBAL", and "KN, mm, C". The Windows taskbar at the bottom shows the time as 8:35 PM on 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

Type here to search

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

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# 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

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# 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

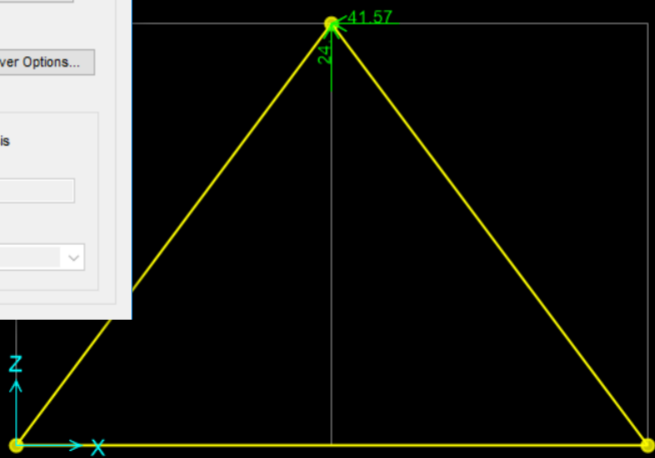
OK Cancel Solver Options...

**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

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# 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

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

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

The screenshot displays the ANSYS software interface. On the left, the 'Joint Displacements' table is shown, detailing the displacement and rotation for three joints. The table is as follows:

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

On the right, a 2D plot shows a triangular structure with nodes at the vertices. The original undeformed shape is shown in grey, and the deformed shape is shown in yellow. A coordinate system with X and Z axes is visible at the bottom left of the plot area. The software interface includes a ribbon at the top with various tool icons and a status bar at the bottom showing 'GLOBAL' and 'KN, mm, C'.

## Post-Processing: Axial Bar Forces

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

Results can also be tabulated

The screenshot displays the SAP2000 v19.2.1 software interface. The main window shows an "Axial Force Diagram (DEAD)" for a truss structure. The diagram features a triangular truss with a horizontal base and two inclined members. The axial forces are visualized as colored bars along the members. A value of  $-29.7$  is shown on the left inclined member, and  $49.64$  is shown on the right inclined member. The horizontal base member is divided into segments. A coordinate system with X, Y, and Z axes is visible at the bottom left.

The "Display Frame Forces/Stresses" dialog box is open, showing the following settings:

- Case/Combo Name: DEAD
- Multivalued Options:  Envelope (Max or Min),  Step (value: 1)
- Display Type:  Force,  Stress
- Component:  Axial Force,  Torsion,  Shear 2-2,  Moment 2-2,  Shear 3-3,  Moment 3-3
- Scaling for Diagram:  Automatic,  User Defined
- Options for Diagram:  Fill 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".

## Post-Processing: Reactions

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

Results can also be tabulated

The screenshot displays the SAP2000 software interface for a truss analysis. The main window shows a truss structure with three joints. The bottom-left joint has reactions  $F1=41.57$  and  $F2=15.71$ . The bottom-right joint has a reaction  $F2=-39.71$ . The top joint is the peak of the truss. A dialog box titled "Display Joint Reactions" 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". The status bar at the bottom indicates "X-Z Plane @ Y=0" and "GLOBAL KN, mm, C". The Windows taskbar at the bottom shows the time as 8:48 PM on 3/12/2018.