Lesson 3
# Using the Beam Calculator

When you complete this lesson, you will be able to:

■ Start SolidWorks;
■ Add-in the SolidWorks Simulation software;
■ Open an existing SolidWorks part;
■ Understand a simply supported beam;
■ Assign a material;
■ Calculate section properties;
■ Use the measure tool;
■ Use the beam calculator to calculate a displacement.

Using Beam Calculations

Before you perform any kind of an analysis, it is a good idea to have some idea on what results to expect. Although you will not know how much weight the structure can withstand, you can make an educated guess on one or more of the results that you will get. This is where beam calculations, simple formulas for beams, can be used. Below are some of the beam calculations available.
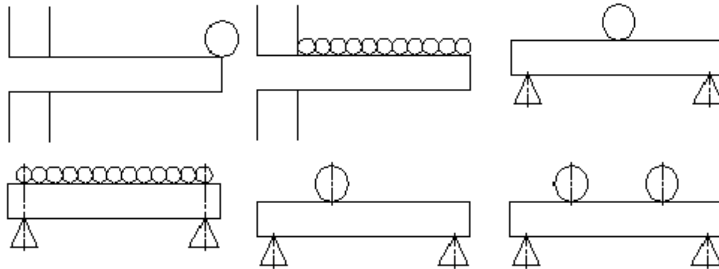
Note: Hand-calculated type beam calculations typically include formulas and look like this.
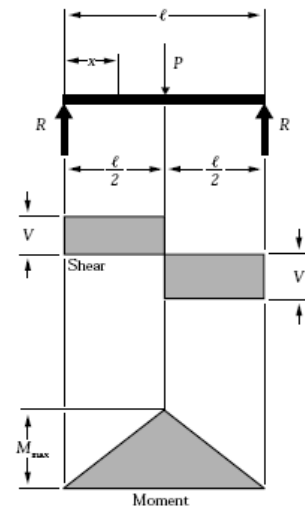
Order of Magnitude

Will the displacement (see "Displacement" on page 11) be close to 1mm? 10mm? The difference is **10** times greater than the previous one and are increasing by what is called an **Order of Magnitude**. An initial calculation can give you an idea of the order or magnitude of the results. This will help you determine whether the analysis has been done correctly.

Questions

1. What is the next value after 1mm and 10mm using an increasing order of magnitude?_____
2. What values are missing in this set? 5mm, _____, 500mm

Starting SolidWorks and Opening a Part

1 Start the SolidWorks application.
From the **Start** menu, click **Programs**, **SolidWorks**, **SolidWorks**.

Adding in SolidWorks Simulation

SolidWorks Simulation software is included with **SolidWorks Education Edition**. To use it, it must be activated using **Tools, Add-Ins**. Click both **Active Add-ins** and **Start Up** for SolidWorks Simulation and SolidWorks Toolbox and click ✅.

2 Add-in selections.
Click **Tools, Add-ins** and make sure that **Active Add-ins** and **Start Up** for both **SolidWorks Simulation** and **SolidWorks Toolbox** are checked.
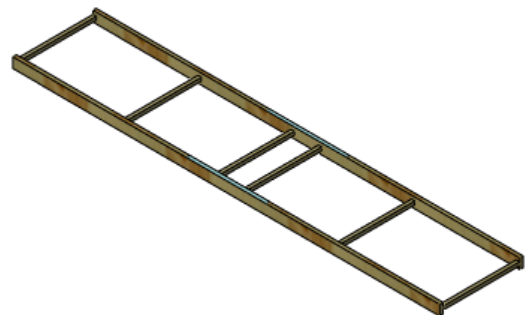
Click ✅.
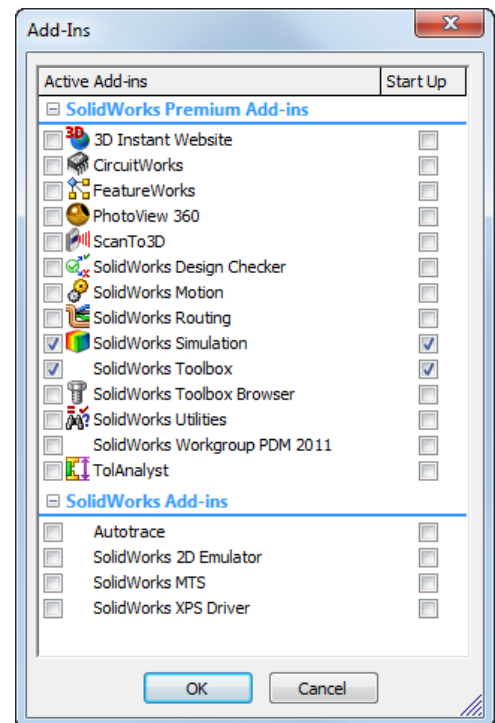
Note: If the SolidWorks Simulation software is not added in the project cannot be completed.

**3 Open the part file.**
Click **Open** 📂.

From the **Open** window, browse to the Bridge Design Project\Student\ Lesson 3 folder.

Select TRUSS_1.sldprt and click **Open**.

The Model Geometry

This model is made up of a series of *beams* that are placed against each other. The beams represent balsa wood sticks. In your project, the beams are combined by gluing them together. In a real structure, the beams would be welded or bolted together.
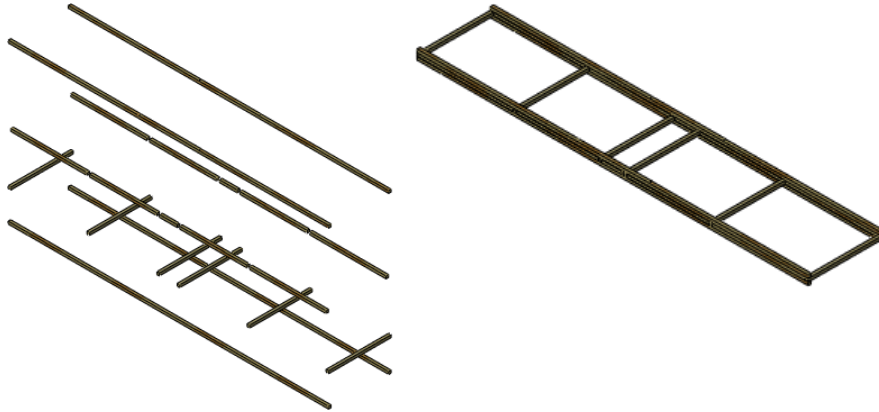
Simplifying the Analysis

The model appears as two parallel beams connected by smaller beams in several places. If we take just half of the model (just the large beam) and apply 1/2 the loads, we should get some idea of what the values will be in the real analysis.
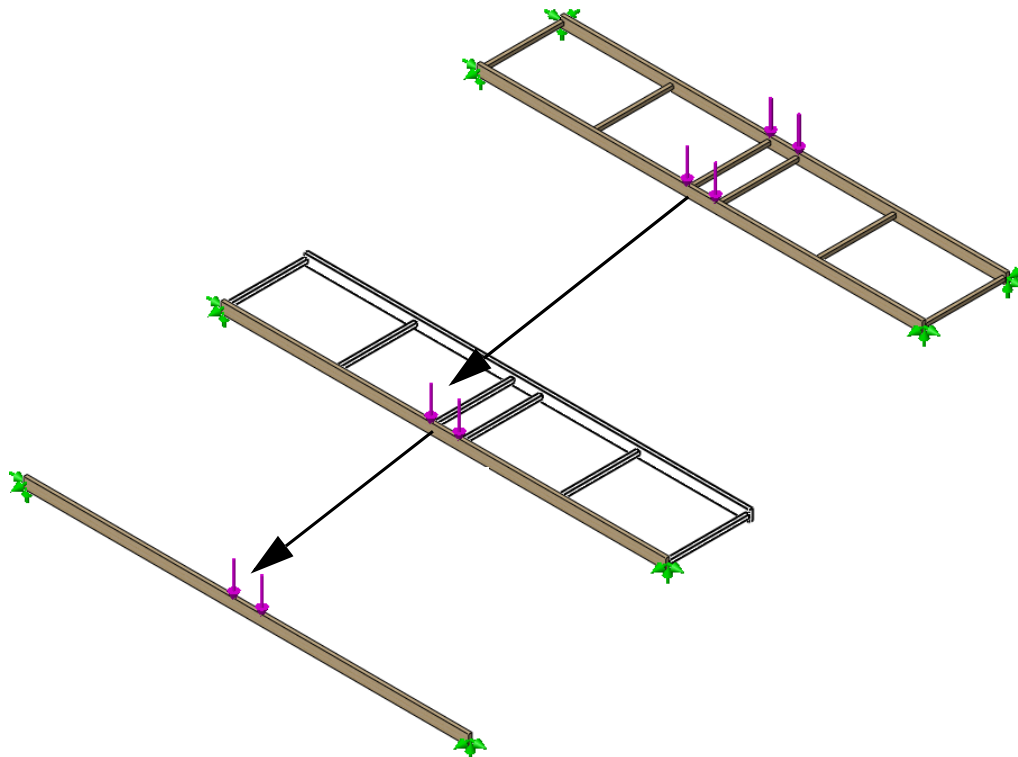
The Simply Supported Beam

This type of beam calculation is often referred to as a "simply supported beam" where the contact points are not completely fixed and a load is applied. There are two key definitions you will need to know; fixtures and external loads.

Fixtures

Fixtures are used to limit movement of certain points in the model. These are usually points of contact. They are also called constraints or restraints.

External Loads

External loads or forces can be used to add **Force** or **Gravity** loads to the structure. Adding a force requires a location on the structure, a value (in Newtons) and a direction.

Theoretical Model

This is the theoretical model (right) of the beam supported by the pencils in the previous lesson.
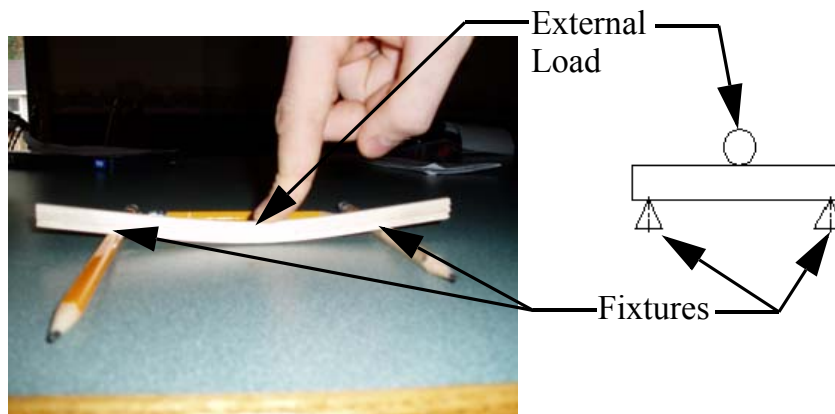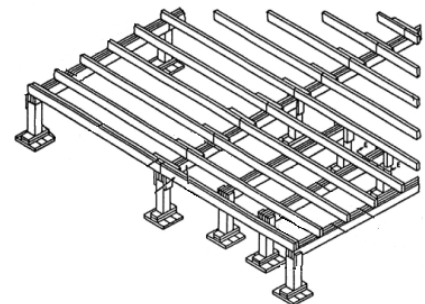

Why are Simply Supported Beams Important?

Although the theoretical model may seem very simple, it has far reaching effects. There are examples of the simply supported beam in use in many places.

Structures

Wood and steel frame spans for homes and buildings are designed using simply supported beams.

Trebuchet

The trebuchet arm rotates on an axis between the frames. The axle is a simply supported beam.

Mountainboard

If you were standing in the middle of a mountainboard, you would be the external load and the wheels would be the fixtures. The structure can be approximated with a simply supported beam.

Note: This example is a "simplified analysis" that takes 3 dimensional problem and simplify it to 2 dimensional problems. A full simulation would still be needed.

Conservative Assumptions

Engineers often use "conservative assumptions" to make the analysis worse than reality for the structure. Doing this adds an extra level safety to the design and makes it stronger than it has to be. Here are some assumptions that will be made:

1. Using the ends of the structure is worse than using the actual points of contact.
2. Using a single external load at the center is worse than two external loads near the center.
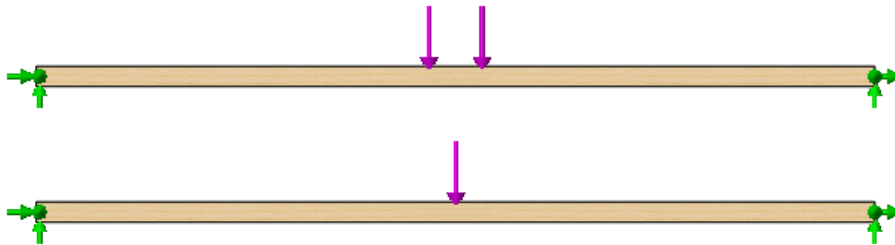
Required Data for the Beam Calculation

There are several pieces of data that are required to use this beam calculation. They include:

Data	Where to Find It?	What is it?
Modulus of Elasticity	Material Properties	Stiffness by material
Moment of Inertia	Section Properties	Resistance to bending
Length	Geometry	Length to cross span
Load	(given)	External load

Common Units

Common metric units are used in this project. Some of the common units used in the SI and IPS (inch, pounds, seconds) units systems are:

Data	SI Units	IPS Units
Modulus of Elasticity	Pa, MPa,	psi
Moment of Inertia	mm^4, cm^4, m^4	in^4
Length	mm, cm, m	in, ft
Load	N, kN	lb

Note: We will use the **SI** unit system in this analysis. The SI system of units is also known as the International System of Units. It uses metric units such as meters., millimeters and Newtons.

Search on **international system of units** for more information.

Collect the Data

The required data will be collected using several different tools in upcoming steps. You will calculate the missing values in the chart below.

Note: As an initial guess, we will assume that the total weight load on the full structure is **40N**. We will use half of that, 40N/2 = **20N**, for the beam calculation.

| Data	Value	Units
Modulus of Elasticity (pressure)	????	Pa (Pascals)
Moment of Inertia (length^4)	????	cm^4
Length	????	mm
Load (force)	20	N (Newtons)

Assign a Material

The first step is to assign a **Material** to the beams of the model. We want to make the structure out of balsa wood.

4 **Material.**
Right-click the Material feature and select **Edit Material**. Expand the SolidWorks Materials and Woods folders on the left and click Balsa.

Under **Units**, select **SI - N/m^2 (Pa)**.

Click **Apply** then click **Close**.
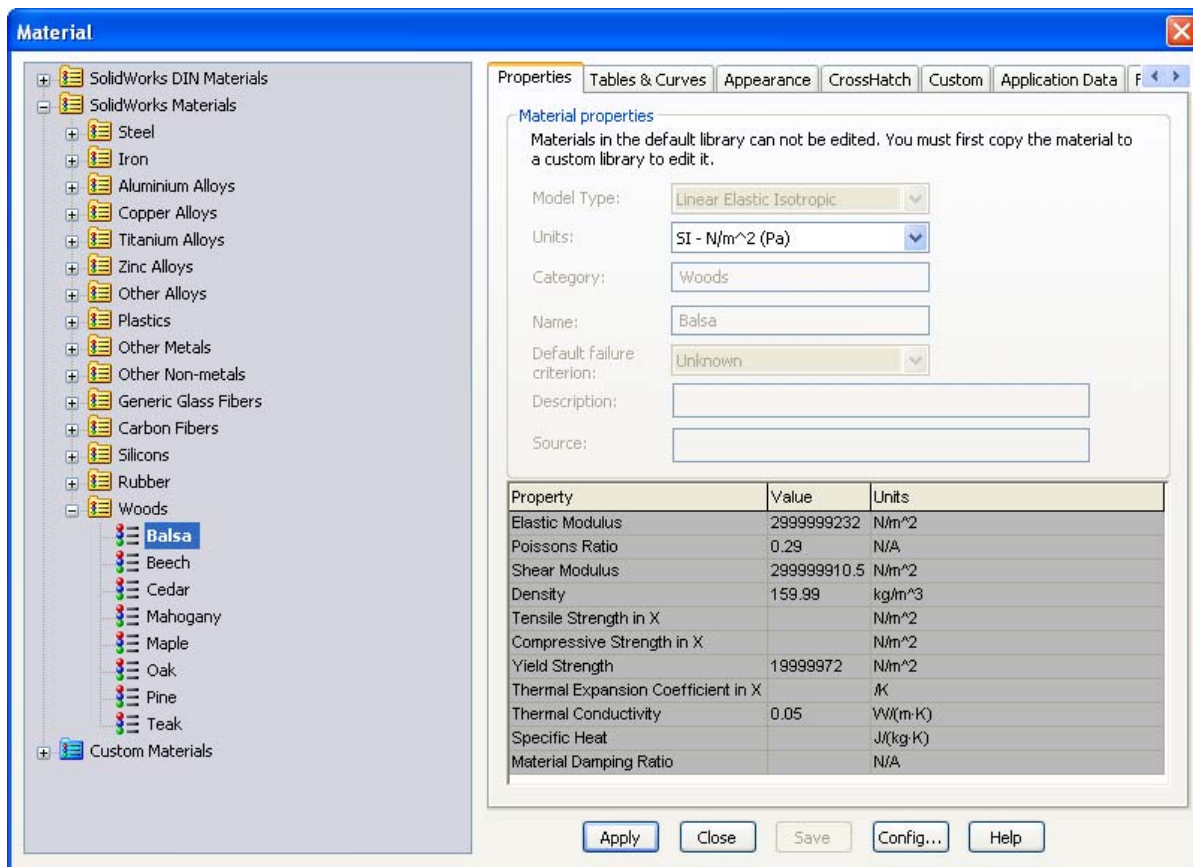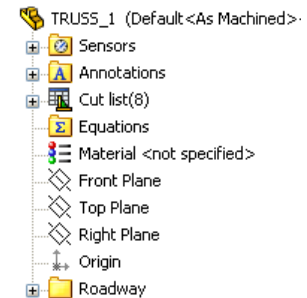
Note: The material used, Balsa, is chosen to make the analysis useful to those who will actually design, construct and test the structure. Balsa wood is a common material for student building projects.

The value of the **Elastic Modulus** or **Modulus of Elasticity** = 2999999232 N/m^2.

*You will learn more about materials, construction and testing in later lessons.

Section Properties

The section properties are based on the cross section of the beam.
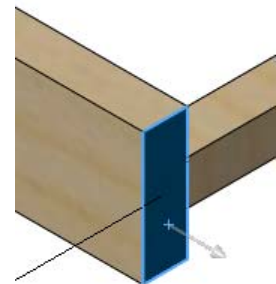
5   Zoom to area.
Click **View, Modify, Zoom To Area** and drag a window, upper left to lower right, around the corner of the structure as shown.
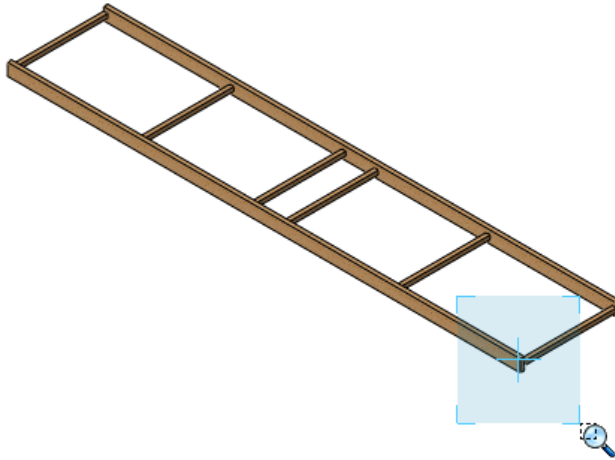
Note: Press the **Esc** key to turn off the zoom tool.

6   Face selection.
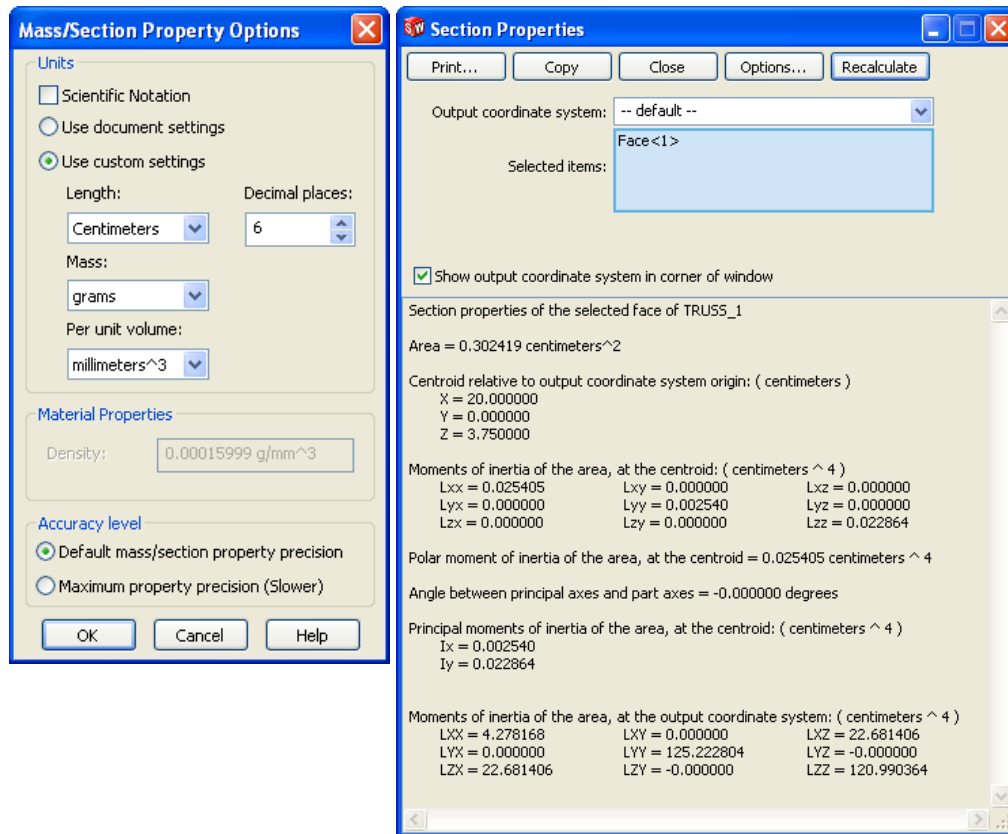Select the face as shown.

7   Section properties.
Click **Tools, Section Properties**. Click **Options** and **Use custom settings**.
Select **Centimeters** and **6** decimal places as shown.

Click **OK** and **Recalculate**.

Moments of inertia of the area, at the centroid: (centimeters ^ 4)
Lxx = 0.025405. Click **Close**.

8   Zoom.
Click **View, Modify, Zoom To Fit** or click the **f** key to return to the full view.
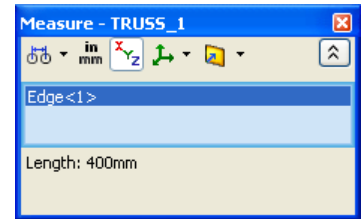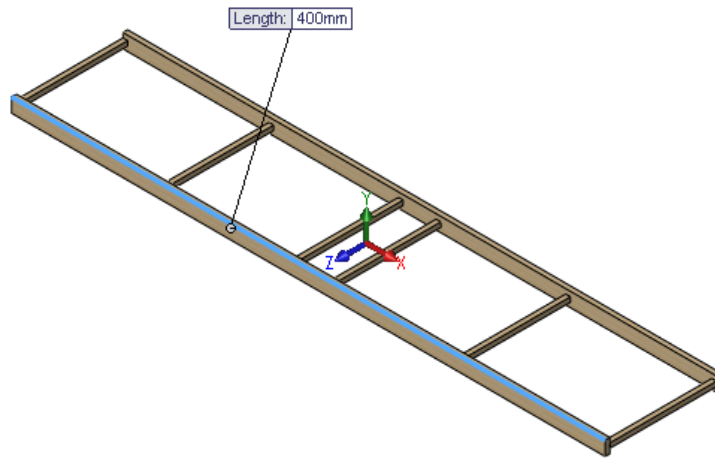
Using Measure

Measure can be used to measure distances or angles using model geometry.

9 Measure.

Click **Tools, Measure**. Select an edge of the beam as shown. The length of the beam is displayed.

Length: 400mm.

10 Close.

Click the "x" in the upper right hand corner of the dialog to close it.

Beam Calculator

The beam calculator uses the input to determine the largest displacement of the beam. Retrieve the data from the chart "Collect the Data" on page 23.

Note: This dialog uses *deflection* but we will be referring to it as *displacement* throughout the manual.

11 Start beam calculator.
Click **Toolbox, Beam Calculator** 📉.

12 Settings.
Clear any values in the **Deflection** field (the **Solve** button will not be available until that field is cleared). Use the scroll bars to access **Supported at both ends, load in middle**. Click **Y local axis**, **Metric** and **Deflection**.

13 Type in values.
Type or copy and paste the values listed below into the dialog:

Data	Value	Units
Modulus of Elasticity (pressure)	**2999999232**	Pa (Pascals)
Moment of Inertia (length^4)	**0.025405**	cm^4
Length	**400**	mm
Load (force)	**20**	N (Newtons)

Click **Solve**. The displacement is about **35mm** at the load (center of the beam). Click **Done**.
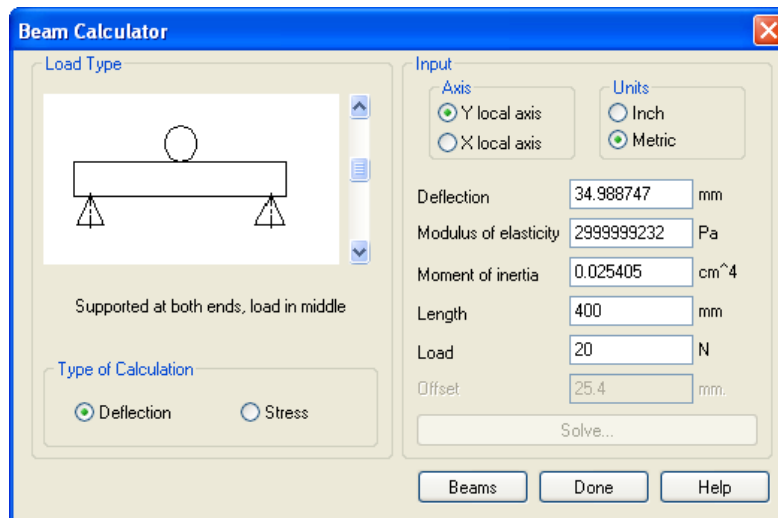
Note: The **Solve** button will not be available until the **Deflection** field is cleared.

Questions

1.   Is this displacement more or less than an inch?_____
2.   Convert the displacement inches: 35mm/25.4 = _____in

14 **Close the part.**
Click **File, Close** to close the part.

At the `Save changes to TRUSS_1?` message, click **Don't Save**.