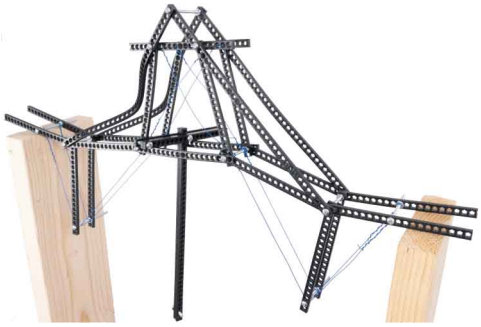
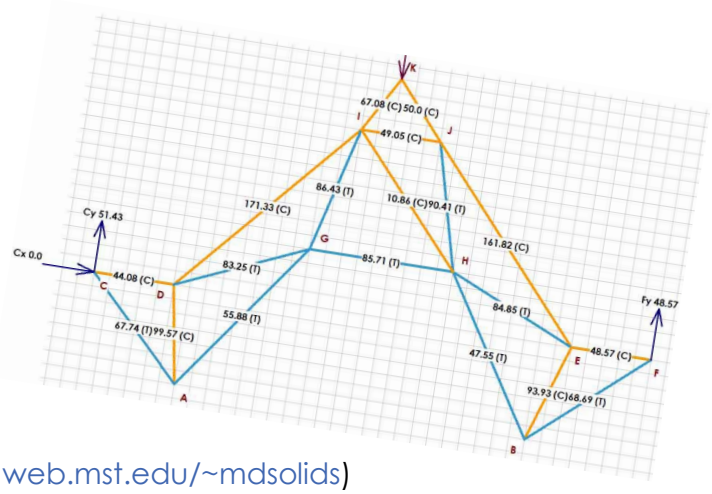
SOFTWARE ANALYSIS BREAKING BRIDGES

TeacherGeek

Name: _____ **Date:** _____

Make your bridge stronger by using software to find the weakest members!





This activity requires:

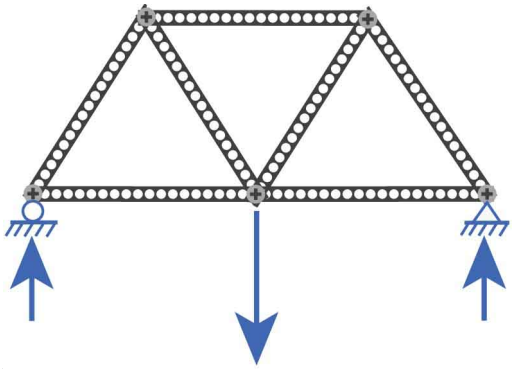
- Breaking Bridges Kit
- PC with MD Solids installed (free at web.mst.edu/~mdsolids)
- Breaking Bridges Design Grid (free at teachergeek.com/bridges)

TRUSS FORCES

What does the MD Solids software tell you about your truss?

The MD Solids software will calculate your truss's reaction forces and member forces. Bridges fail when member forces get too large.

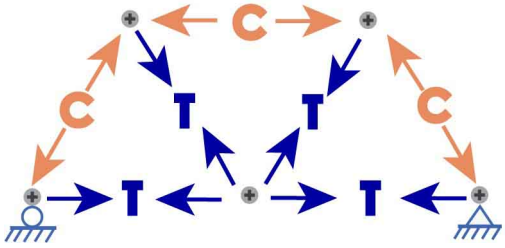
Reaction Forces



Reaction force (abutment pushing bridge) | **Load** (weight pulling bridge) | **Reaction force** (abutment pushing bridge)

When your bridge carries a load, it transfers the force of the load to the abutments. As the bridge pushes down on the abutments, the abutments push back – this is called a Reaction Force.

Member Forces

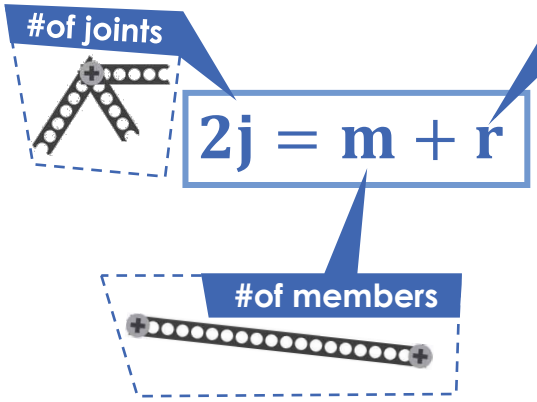


Member forces *within* the truss transfer the load through the bridge to the abutments. Each joint of the truss experiences forces from members that are in **T**ension or **C**ompression.

DETERMINATE TRUSSES

Can MD Solids model your truss?

The MD Solids software only works if your truss is statically determinate (can be solved with basic "laws" of physics). For a truss to be statically determinant, the equation below must be true:



MD Solids will require you to add supports, which allow a bridge to move slightly on its abutments. Bridges must move as they expand and contract from changing loads and temperatures.

2 Forces

Pin Support

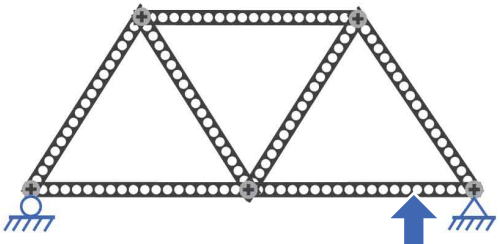
Pin supports provide two reaction forces – one horizontal and one vertical.

1 Force

Roller Support

Roller supports let the bridge move horizontally, so they only provide one vertical reaction force.

Example 1:



$2j = m + r$?

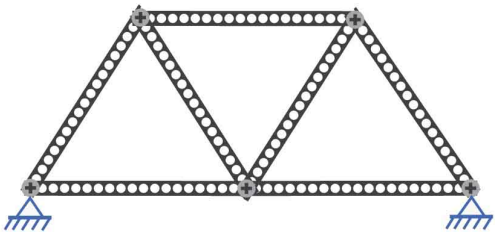
$2(5) = 7 + 3$?

$10 = 10$ ✔

This bottom strip has a joint in the middle, so it counts as two members.

This truss **CAN** be modeled in MD Solids! It's statically determinate.

Example 2:



$2j = m + r$?

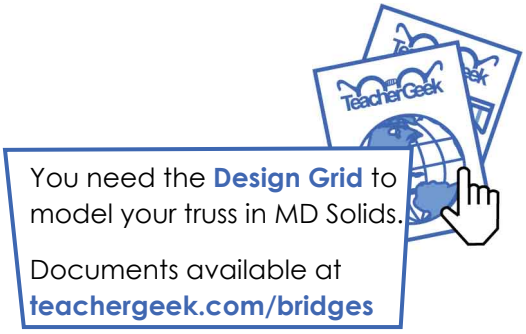
$2(5) = 7 + 4$?

$10 \neq 11$ X

This truss **CANNOT** be modeled in MD Solids! It's NOT statically determinate.

DESIGN YOUR TRUSS

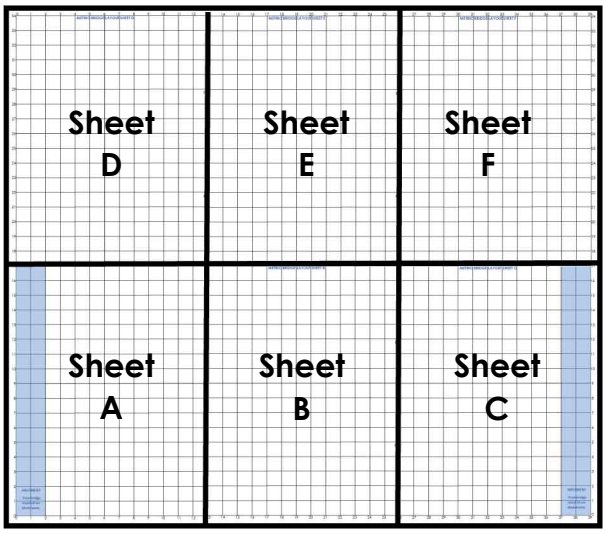
Build a truss to model!



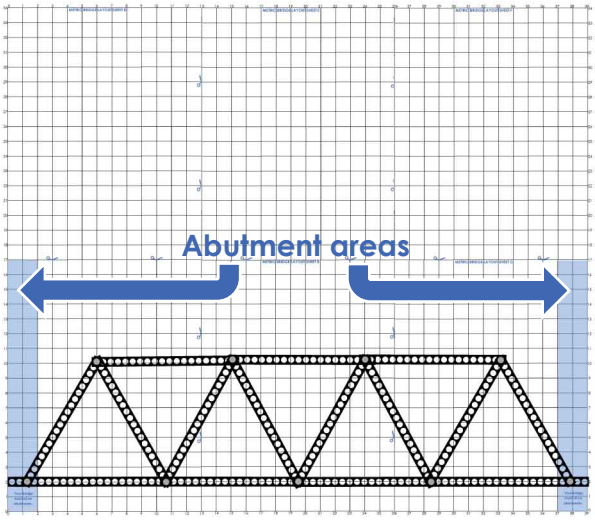
You need the **Design Grid** to model your truss in MD Solids.

Documents available at **teachergeek.com/bridges**

1 Cut and **assemble your Design Grid**, as shown.



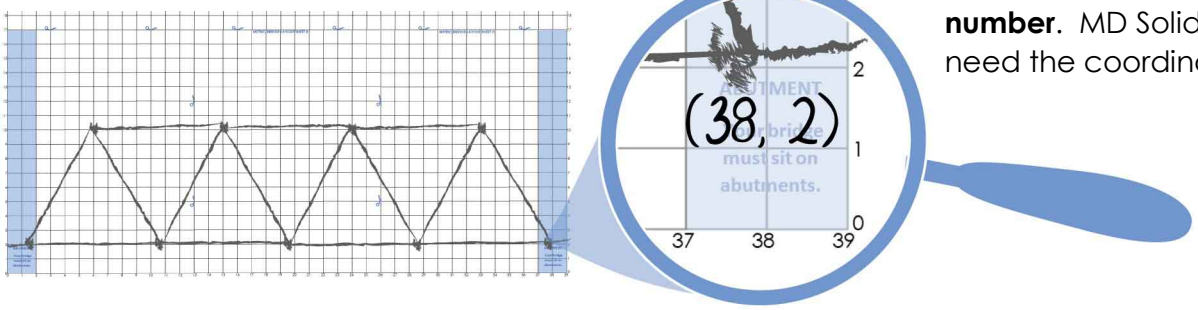
2 **Lay your parts on the grid to design your truss**. Make sure your bridge is long enough – it must cross into the shaded abutment areas.



3 **Make sure** your design can be modeled. It must be:

- ☐ **made of triangles**
- ☐ **statically determinate** (**use r=3** for one pin and one roller support)

4 **Sketch your truss** on the grid and remove your parts.

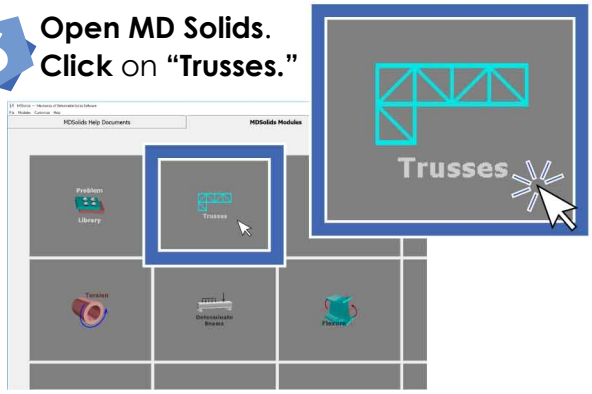


5 **Add coordinates** next **to each joint**. **Round** to the **nearest whole number**. MD Solids will need the coordinates.

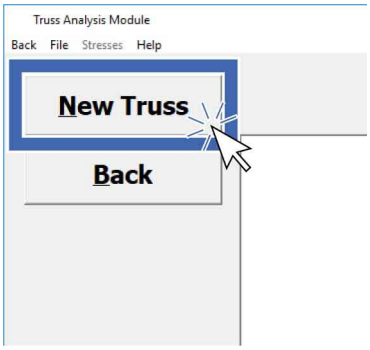
MODEL YOUR TRUSS

Make your truss in MD Solids!

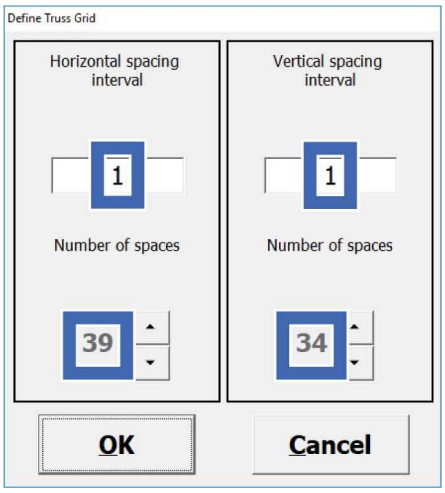
6 **Open MD Solids. Click** on **"Trusses."**



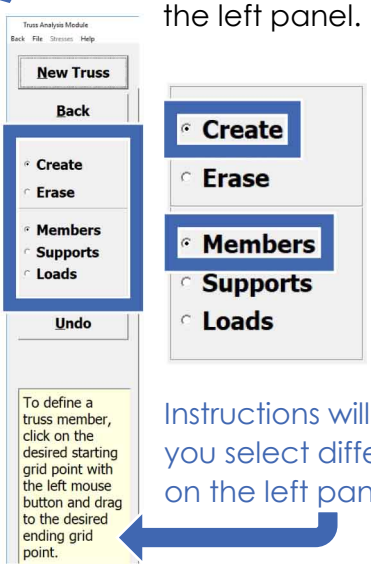
7 Next **click "New Truss."**



8 **Set the intervals and spacing** as shown.

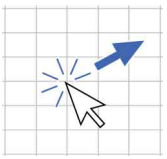


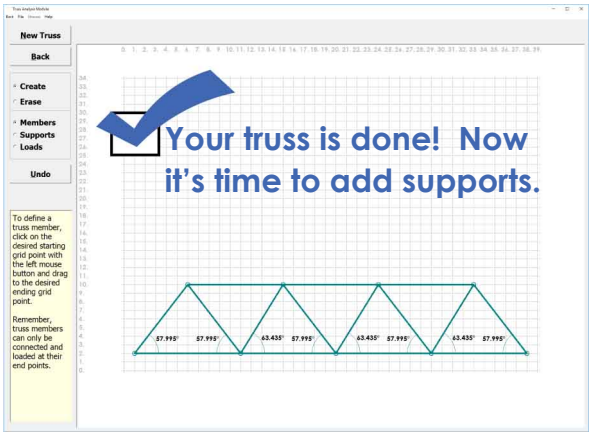
9 Get ready to add members – **click "Create" and "Members"** in the left panel.



Instructions will appear as you select different options on the left panel.

10 To create your truss, **click and drag from joint to joint**. Use the coordinates from your grid.





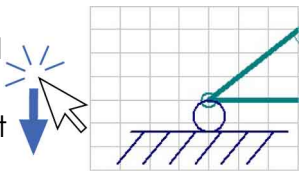
Tip

Need to erase a member? Select "Erase," then click and drag from one endpoint to another.

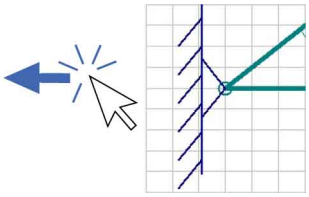
ADD SUPPORTS

11 Prepare to add supports by **selecting** "**Create**" and "**Supports**."

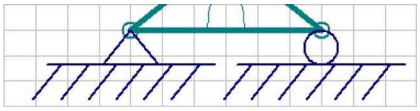
12 To **add** a **roller support**, **click and drag vertically** on a joint that will rest on an abutment.



13 **Make a pin support** by **clicking and dragging horizontally** on **the roller**. It is ok the pin appears sideways.



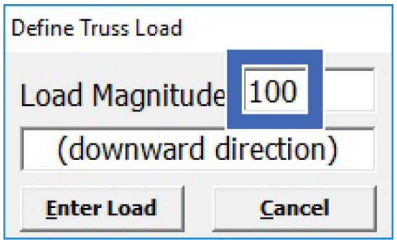
14 **Create a roller support at the other joint** where your bridge will contact an abutment. It is ok if your supports appear upside down.



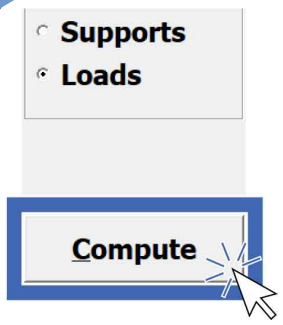
TEST YOUR BRIDGE!

15 **To add a load:**

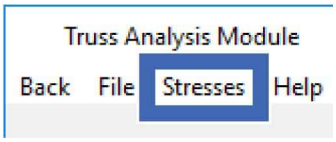
- **Select "Create"** and **"Loads."**
- **Click and drag down** at the joint closest to the middle.
- Use a "**Load Magnitude" of 100.**



16 **Click "Compute."**



17 **Click "Stresses"** at the top to view the member forces in a table.



18 **Click "Print"** to print the table and diagram.

Normal Stresses in Truss Members

Back Edit Print

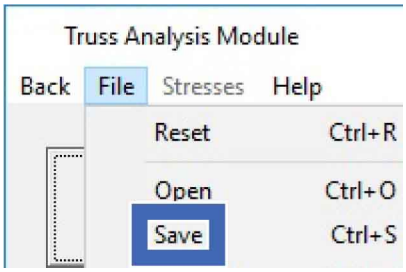
Member	Force
	(lb)
AC	67.735
AD	-99.572

Disregard the units. Think of the member forces as a percent of your total load (100).

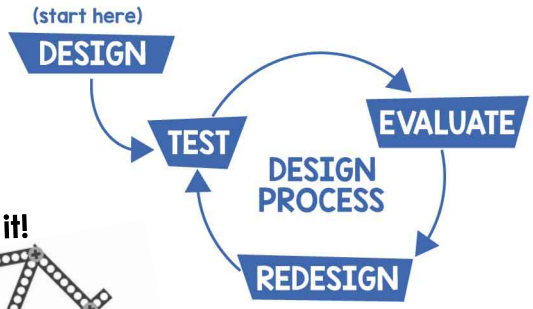
Positive forces are tension.

Negative forces are compression.

19 **Save your truss** as a **.dat** file so you can access it later.

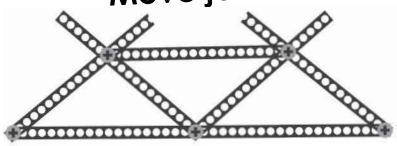


MAKE IT BETTER!

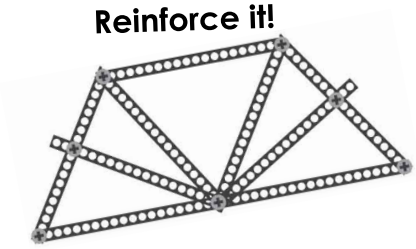


Keep refining your design in MD Solids, then build it for real!

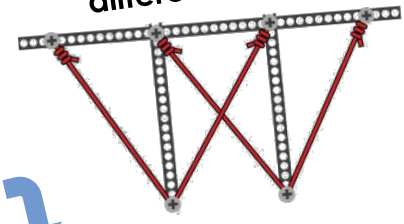
Move joints!



Reinforce it!



Explore entirely different designs!



Find out how the software works with the **Physics Analysis Activity**!

Documents available at **teachergeek.com/bridges**

OPTIONAL

BUCKLE UP!

Don't let buckling break your bridge!

Members usually fail more readily in compression than in tension. This is because members in compression can *buckle*, especially if they are long and thin.

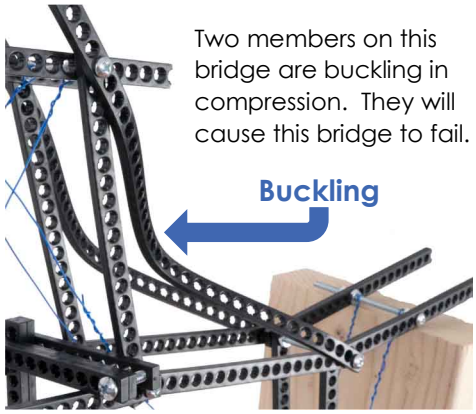
To find the members most likely to buckle, multiply each member's compressive force by the square of its length (you will have to measure it). This quantity has no official name, but it can be called the "buckling index."

The greater the magnitude of the buckling index, the more likely a member is to buckle.

Find the buckling index for your bridge's compression members to see where you need to reinforce your bridge!

$B = FL^2$, where

- B is the **buckling index**
- F is **member force**
- L is the **member length**



Two members on this bridge are buckling in compression. They will cause this bridge to fail.

Example:

Member	Force (lb)
AC	+60.000
AD	-60.000
AG	-20.000

Length	Buckling Index
SKIP	(it's in tension)
10cm	-6000
30cm	-18000 This one will fail first!