

Student Packet

Bridging Mathematics and Science

6th to 8th grade Mathematics and Science Activities

55th West Virginia Council of Teachers of Mathematics Meeting March 21, 2003 Flatwoods, WV

Work by

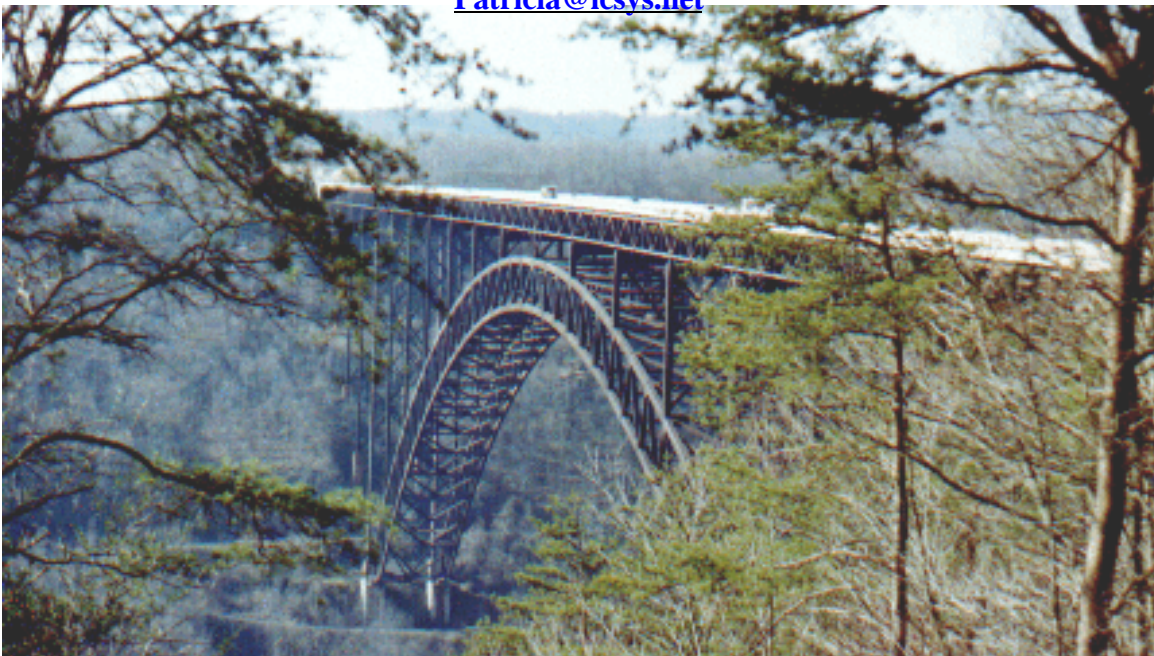
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Deflection of a Cantilevered Beam Activity

Deflection – the amount that a material bends when a force is applied to it.

Materials:

- Thin, narrow, and long piece of wood (like a meter stick)
- Meter stick for measuring
- Clamps or books (to fasten the wood to the end of a desk)
- Set of standard masses
- String
- Scissors

Procedure:

1. Prepare the data table.
2. Place a meter stick on the desk.
3. Position the meter stick so that at least 50 cm. of the stick hangs over the edge of the desk. (Each team may select a different overhang)
4. Using a clamp, secure the meter stick to the desk.
5. Record the mass of 0 as the first mass into the table.
6. Measure the height of the free end of the meter stick above the floor, using either the top or the bottom of the stick.



7. Record this measurement into the column height of the end without a mass.
8. Record this measurement into the table as the first height of end with mass (mass of 0.)
9. Add a mass to the free end of the meter stick using a string.
10. Record the mass into the table as the next mass.
11. Measure the height of the weighted end of the meter stick using same the reference as in step 6 (top or bottom.)



12. Record this measurement into the table as the next height of end with mass.
13. Fill in the deflection entry by subtracting the height of end with mass entry from the height of end without mass entry.
14. Repeat steps 9 through 13 for several masses.

Deflection Data Table

Names: _____

Date: _____

Overhang: _____ cm.

mass (g).	deflection (cm.)	height of end without mass (cm.)	height of end with mass (cm.)

Distribution of the Load in the Supports of a Beam Bridge Activity

Activity on the Distribution of the Load

Names: _____

Date: _____

About this Activity

In this activity you will learn how the position of a load on a beam bridge affects the force at its supports. You will collect and then record data in both tables and graphs. You will use mathematics to model your activity and to help answer questions about beam bridges. You will learn how to find the line of best fit for your data using a TI-73 graphics calculator. A line of best fit minimizes the total distance from all of the points you have plotted to the line.

Imagine a board that spans a creek. You wish to sit on the board so that your weight is distributed evenly between both ends. Where would you sit? Why? Most likely, your response to the first question was, "In the middle." But, you probably found it a little difficult to explain this response. Following is a modeling activity that shows how mathematics can help explain why you should sit in the middle.

Data Collection

1. Make sure you have the following:
 - 1 - TI-73 Graphic Calculator
 - 1 - 3" X 1/8" X 18" (7.6cm. X .3 cm. X 45.7 cm) piece of balsa wood
 - 1 - metric ruler
 - 2 - 200g electronic balances
 - 2 - 225g/25 newton spring scales
 - several mass weights (approximately 100g each)
 - 2 - pencils or pens to use as supports between balance and balsa wood.
 - 1 - meter stick
 - string, tape, desks or tables
2. Begin your activity by setting up your beam bridge model.
 - Mark the balsa wood 2.8m. in from one end with a ball point pen. (This is position "0" and will be placed on one support.) Continue to mark the wood in 4 cm. intervals

labeling each position through position 10. (Position “10” will be placed over the second support.)

3. You need to span two supports with the balsa wood. Place the two supports (pens or pencils) one each in the center of the electronic scales. Make sure that you place position “0” of the balsa wood over one support and position “10” over the other.
4. “Zero” the balances.
5. Place a mass weight at position “0” and record the *Right* and *Left* mass readings in the table below. Continue collecting data by moving the mass from one mark to the next along the balsa wood until you have entries for 11 positions in your table.



6. Once you have recorded your data into the *Right* and *Left* columns in the table, fill in the remaining columns.

Distribution of the Load Data Table

Position	Right Balance (g)	Left Balance (g)	Right + Left	Right - Left	Right X Left	Right/ Left
0						
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

Assignment

Once the table is completed answer the following:

1. There should be a pattern between the numerical entries in the Right Balance and Left Balance Columns, What is it?
2. What does this pattern allow you to conclude about the force and load on beam bridges?
3. Which other columns seem to generate interesting patterns?
4. What do you think these patterns are telling you about the load and force on beam bridges?
5. How can you use your table to predict the location where the load is distributed evenly between both supports?

Use graphing paper to make a complete graph

Let Right Balance (g) be the independent value or x-axis heading, and let Left Balance (g) be the dependent value or y - axis heading. You will receive points for labeling the axes with the appropriate headings (not x and y). You should give your graph a title. Make sure that you label enough information so that the scale(s) that you use on the axes is/are evident.

Once you have constructed the graph, answer the following:

1. What **type** of **curve** relates the Right Balance reading to the Left Balance Reading? Choose a “fit curve”: Line Parabola Circle

Try to pencil in a “fit curve” onto your graph based on your selection above. Your “fit curve” should be as close to as many of your points as possible. (It probably won’t go through all of your points.)

Choose any two pairs of Right and Left Balance data from your table and fill the information for the two related points here:

(,) (,)

Remember that given any two points on a line that is not vertical, you can calculate the slope of the line by calculating the difference of the “y” values over the difference of the “x” values. You can use these two points to approximate the slope of your line.

2. Calculate the slope of your line here:
Remember that the y-intercept of a graph occurs when the x coordinate is zero.
3. What is your y- intercept?
4. At which position was the mass weight when you collected data that was close to the y - intercept?
5. At which position was the mass weight when you collected data that was close to the x- intercept?

Distribution of the Load in the Supports of a Beam Bridge Activity

Use a graphics calculator to graph your data

1. Turn on your graphics calculator.

To Enter your Data from a Table:

2. Select **LIST**.
3. Use the arrow keys to highlight **L1** and select **Clear** **Enter**.
4. Use the arrow keys to highlight **L2** and select **Clear** **Enter**.
5. Move to the first cell under **L1** and enter your right scale values.
6. Select the right arrow key to move to **L2**, and enter your related left scale values.
Press **2nd** **QUIT** when done.

To Turn on a Plot:

7. Select **2nd** **PLOT** and use the arrow keys to highlight **1**.
8. Select **ENTER**.
9. Using the arrow keys and the **ENTER** key, make sure that **Plot 1** is turned **On**, and choose to make a **Scatter Plot**. By default, **Xlist** is **L1** and **Ylist** is **L2**. Choose any **Mark** type that you wish.
10. Select **2nd** **PLOT** and make sure all other plots are turned off (use steps 8 and 9 above if necessary.) Press **2nd** **QUIT** when done.

To See a Plot:

11. Press **Y=** and use **CLEAR** and the arrow keys to clear old equations.

12. Press **GRAPH** **ZOOM** and then select **7** to see all of the points from your table.

To Make a Manual Fit Line:

13. Select **2nd** **STAT** **CALC** and select **3** for **Manual-Fit**.
14. Move the cursor to the upper left to begin your fit line and select **ENTER** to tie down a point on the line.
15. Using the arrow keys continue the line segment and then select **ENTER** to tie down the second point, your manual-fit line is drawn.
16. What is the equation of the line of manual-fit? $y = \underline{\hspace{2cm}}$ (as it appears on your calculator screen.)
17. You may move the arrow keys to move the line until you select **Enter**.

To Make a Fit Line Using a Linear Regression:

18. Select **2nd** **STAT** **CALC** and select **5** for a **Linear Regression**.
19. Select **2nd** **VARS** select **2, 1, ENTER** to place your fit equation into the Y1 equation.
20. $a = \underline{\hspace{2cm}}$ $b = \underline{\hspace{2cm}}$
21. Select **Y=**
22. What is the equation of the line of best fit? $Y1 = \underline{\hspace{2cm}}$ (as it appears on your calculator screen.)
23. What is the y-intercept of the line of best fit? $\underline{\hspace{2cm}}$
This number should be close to representing something you used when measuring.
What is it? $\underline{\hspace{2cm}}$
24. What is the slope of the line of best fit? $\underline{\hspace{2cm}}$

25. What does x represent in this problem? _____
26. Which number values make sense for x and why? _____
27. What does y represent in this problem? _____
28. Which number values make sense for y and why? _____
29. Select **GRAPH**

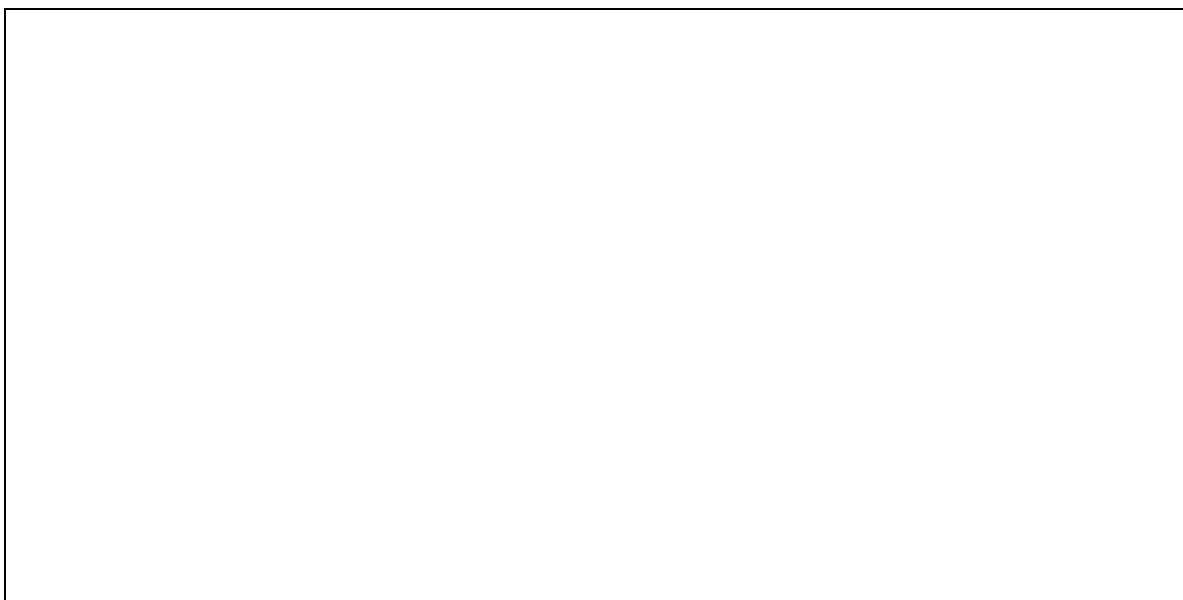
To Zoom In:

30. Press **ZOOM** then select **2**

Describe how the calculator graph compares with your hand drawn graph for this activity and describe how are the two graphs different?



Now once again, imagine a board that spans a creek. You wish to sit on the board so that your weight is distributed evenly between both ends. Where would you sit? Why?



Extension Exercise

1. Begin your activity by setting up your beam bridge model.
Using the balsa wood from the previous activity, you need to span two spring scales hung from a meter stick. Use string and tape to support the balsa wood from the scales. One string supports should be placed at position “0” of the balsa wood the support at position “10”.
2. “Zero” the scales.
3. Place your mass weight at position “0” and record the *Right* and *Left* mass readings in the table below. Continue collecting data by moving the mass from one mark to the next along the balsa wood until you have entries for 11 positions in your table.
4. Once you have recorded your data into the *Right* and *Left* columns in the table, fill in the remaining columns

Distribution of the Suspended Load Data Table

Position	Right Scale (g)	Left Scale (g)	Right + Left	Right - Left
0				
1				
2				
3				

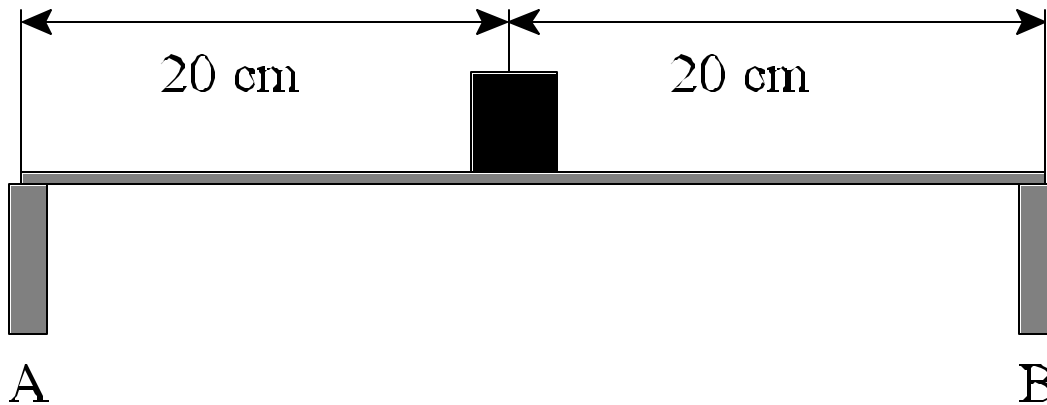
4				
5				
6				
7				
8				
9				
10				

What generalization can you make about force distribution and supports whether attached above or below a beam bridge?

Questions to Think About

You and a friend each hold the end of a pole. On the pole is a pail of sand.

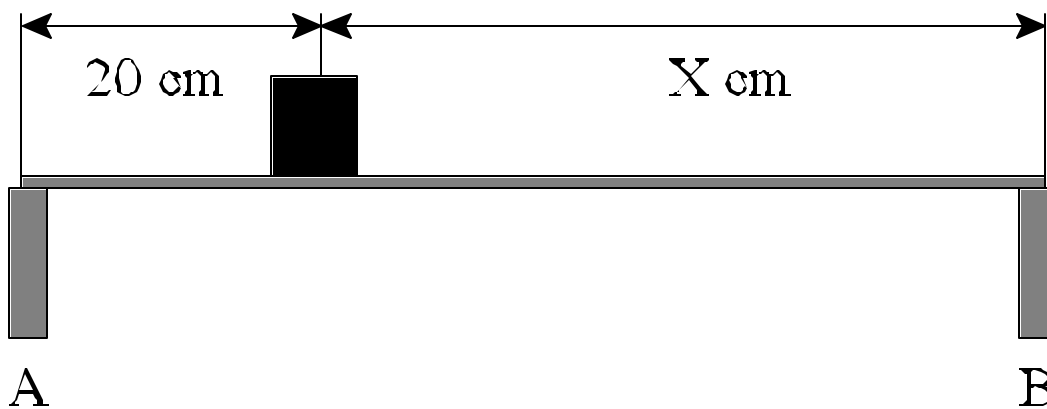
1. Where would you place the pail so that you support less of the load?
2. If the pail is “stuck” in the center of the pole, what could you do to support more of the load?
3. The force exerted by the box on the beam bridge is 15 N.



What is the force supported by end support A ? _____

What is the force supported by end support B ? _____

4. The force exerted by the box on the beam bridge is 8 N.



The force supported by end support A is 2 N.

What is the distance X ? _____

What is the force supported by end support B ? _____

Student Truss Bridges

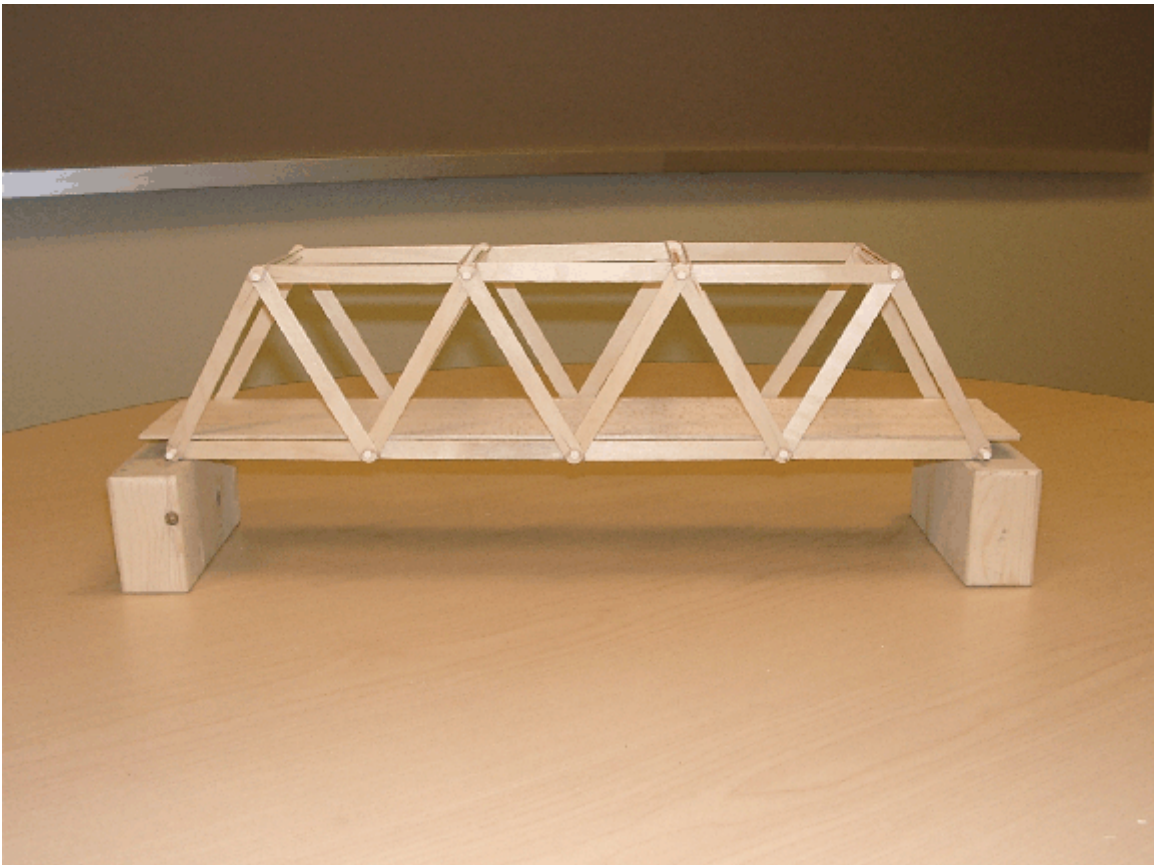
Students will work with a partner and construct a truss bridge.

Students will be given a Ziploc bag with the following contents:

- 30 popsicle sticks (hole drilled at each end)
- 9 lollipop sticks – 4 in.
- 9 straws – 3 in. length
- 9 rubber bands
- 1 3" X 1/8" X 18" (7.6cm. X .3 cm. X 45.7 cm) piece of balsa wood

Students will see a completed truss bridge and construct one like the model.

When the bridges are completed, students will compare the models.



Deflection of a Bridge Activity

Names: _____

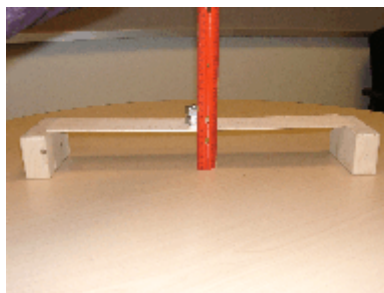
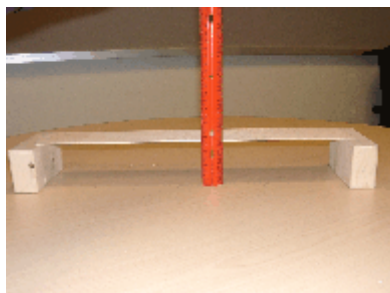
Date: _____

About this Activity

In this activity, you will learn how the addition of a truss structure affects the deflection. You will also explore trusses that are attached above and below a beam bridge. You will collect and then record data in tables in order help answer questions about truss bridges

Data Collection

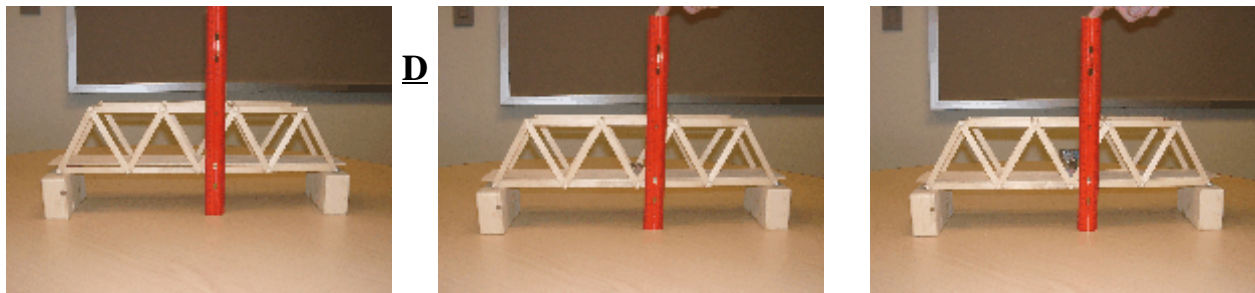
1. Make sure you have the following:
 - 1 - Truss Bridge Model from the Truss Bridge Activity
 - 1 - Metric Ruler
 - Several Mass Weights (approximately 100g each)
 - 2 - Pencils or Pens to use as supports between support and balsa wood.
 - 2 - Wooden Block Supports
2. Begin your activity by using only the beam bridge model portion of the truss bridge.
3. You need to span two block supports with the balsa wood. Make sure that you place position "0" of the balsa wood over one support and position "10" over the other.
4. Place a mass weight in the center of the beam bridge and record the mass, height without the mass, and deflection in the table below. Continue collecting data by adding enough mass until you have entries for 6 positions in your table.



Deflection of a Beam Bridge Data Table

No Truss			
Mass (g)	Height w/o mass (cm.)	Height with mass (cm.)	Deflection (cm.)
0			

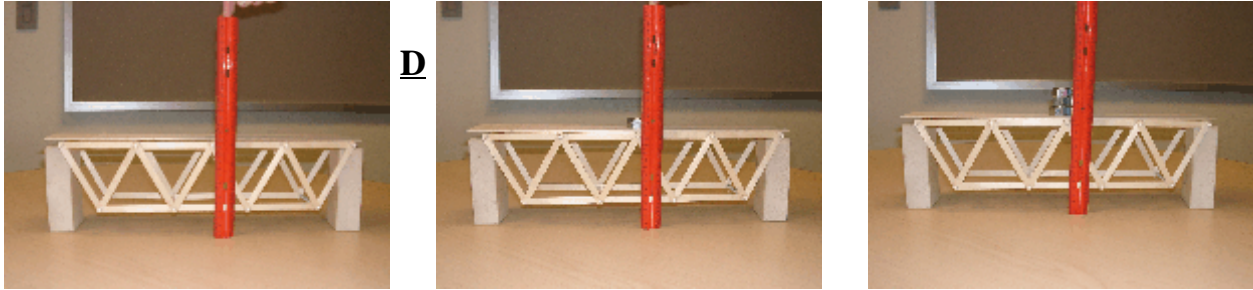
5. Repeat the data collection for the truss bridge. Use the same mass entries as those in the first table.



Deflection of a Truss Bridge Data Table

Truss			
Mass (g)	Height w/o mass (cm.)	Height with mass (cm.)	Deflection (cm.)
0			

6. Repeat the data collection for the inverted truss bridge. Use the same mass entries as those in the first table.



Deflection of an Inverted Truss Bridge Data Table

Inverted Truss			
Mass (g)	Height w/o mass (cm.)	Height with mass (cm.)	Deflection (cm.)
0			

7. Explain how a truss structure affects the deflection of a bridge.
8. Does there seem to be a difference in the deflection between the non-inverted and inverted truss bridge?

Use a graphics calculator to graph your data

1. Turn on your graphics calculator, Select **MODE** arrow down to **Float** and use the right arrow to highlight 5 and **ENTER**. Press **2nd** **QUIT** when done.

To Enter your Data from a Table:

2. Select **LIST**.
3. Use the arrow keys to highlight **L1** and select **Clear** **Enter**.
4. Use the arrow keys to highlight **L2** and select **Clear** **Enter**.
5. Move to the first cell under **L1** and enter your mass data.
6. Select the right arrow key to move to **L2**, and enter your data for deflection of a beam bridge. Press **2nd** **QUIT** when done.

To Turn on a Plot:

7. Select **2nd** **PLOT** and use the arrow keys to highlight 1.
8. Select **ENTER**.
9. Using the arrow keys and the **ENTER** key, make sure that **Plot 1** is turned **On**, and choose to make a **Scatter Plot**. By default, **Xlist** is **L1** and **Ylist** is **L2**. Choose any **Mark** type that you wish.
10. Select **2nd** **PLOT** and make sure all other plots are turned off (use steps 8 and 9 above if necessary.) Press **2nd** **QUIT** when done.

To See a Plot:

11. Press **Y=** and use **CLEAR** and the arrow keys to clear old equations.

12. Press **GRAPH** **ZOOM** and then select **7** to see all of the points from your table.

To Make a Manual Fit Line:

13. Select **2nd** **STAT** **CALC** and select **3** for **Manual-Fit**.
14. Move the cursor to the upper right to begin your fit line and select **ENTER** to tie down a point on the line.
15. Using the arrow keys continue the line segment and then select **ENTER** to tie down the second point, your manual-fit line is drawn.
16. What is the equation of the line of manual-fit? $y =$ _____ (as it appears on your calculator screen.)
17. You may move the arrow keys to move the line until you select **Enter**.

To Make a Fit Line Using a Linear Regression:

18. Select **2nd** **STAT** **CALC** and select **5** for a **Linear Regression**.
19. Select **2nd** **VARS** select **2, 1, ENTER** to place your fit equation into the Y1 equation.
20. $a =$ _____ $b =$ _____
21. Select **Y=**
22. What is the equation of the line of best fit? $Y1 =$ _____ (as it appears on your calculator screen.)
23. What is the y-intercept of the line of best fit? _____
24. What is the slope of the line of best fit? _____
25. What does x represent in this problem? _____

26. Which number values make sense for x and why? _____
27. What does y represent in this problem? _____
28. Which number values make sense for y and why? _____
29. Select **GRAPH**

Repeat the process for the truss bridge data using Lists 1 and 3 for StatPlot2 and the inverted truss bridge data using lists 1 and 4 and StatPlot 3. (You may skip the manual fit for these two sets of data.)

To Enter your Truss and Inverted Truss Data from a Table:

1. Select **LIST**.
2. Use the arrow keys to highlight **L3** and enter your deflection data for Truss bridge.
3. Use the arrow keys to highlight **L4** and enter your deflection data for Inverted Truss bridge
4. Press **2nd** **QUIT** when done.

To Turn on a Plot:

5. Select **2nd** **PLOT** and use the arrow keys to highlight **2**.
6. Select **ENTER**.
7. Using the arrow keys and the **ENTER** key, make sure that **Plot 2** is turned **On**, and choose to make a **Scatter Plot**. By default, **Xlist** is **L1**.
8. Arrow down to **Ylist**. Select **2nd** **Stat** **3** **ENTER** to use List 3. Use any **Mark** type that you wish.
9. Select **2nd** **PLOT** and use the arrow keys to highlight **3**.
10. Select **ENTER**.

11. Using the arrow keys and the **ENTER** key, make sure that **Plot 3** is turned **On**, and choose to make a **Scatter Plot**. By default, **Xlist** is **L1**.
12. Arrow down to **Ylist** Select **2nd** **Stat** **4** **ENTER** to use List 4. Use any **Mark** type that you wish.
13. Select **2nd** **PLOT**
14. Select **GRAPH**
15. If you look carefully, you should see three scatter plots in your viewing window. Use them to answer the following:
A) If the mass is constant, is there a significant difference in deflection between a truss that is above or one that is below the beam bridge? Explain.
B) How does the use of a truss affect the deflection of a beam bridge? Explain.

A)

B)