HOOKE'S LAW LAB
BREAKING BRIDGES

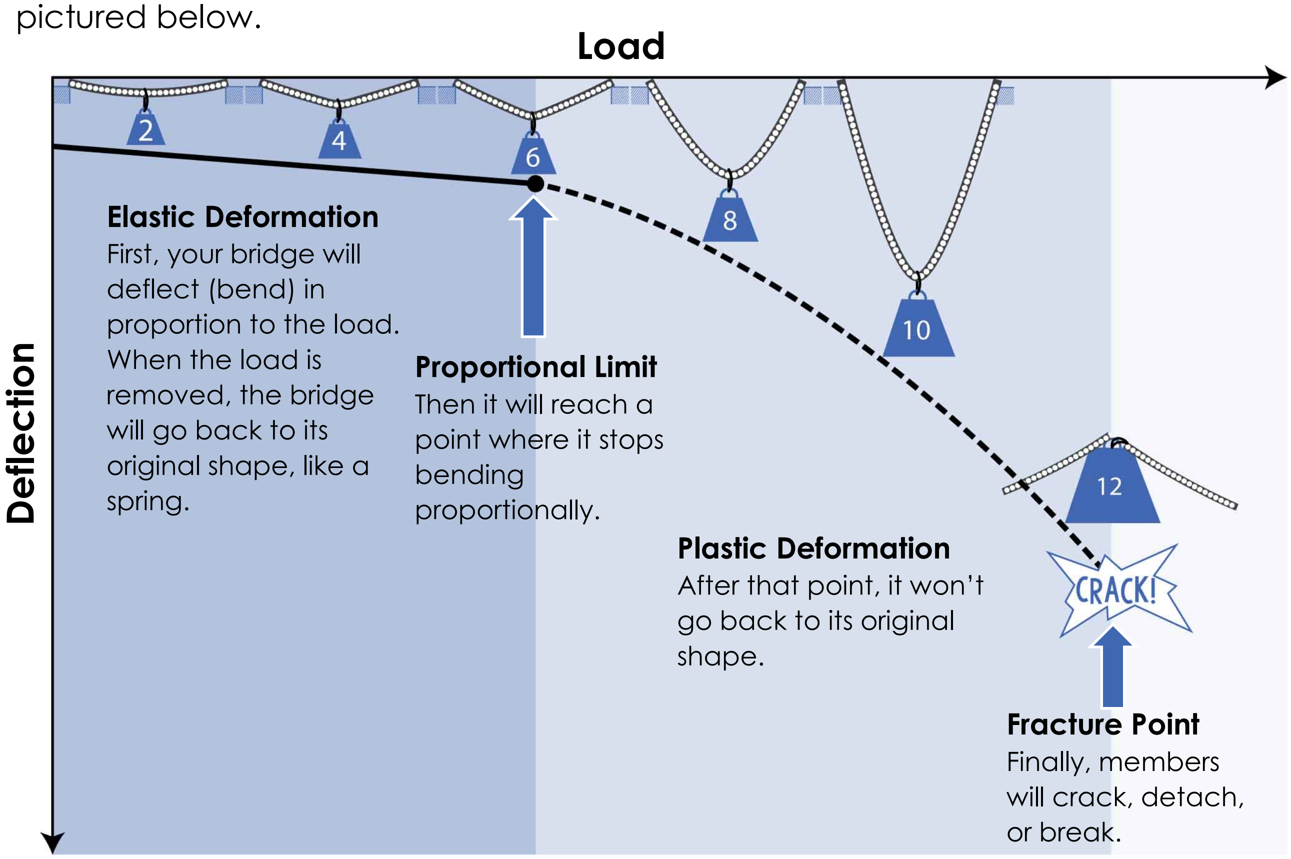
TeacherGeek

Name: ____________________ Date: ____________

BACKGROUND

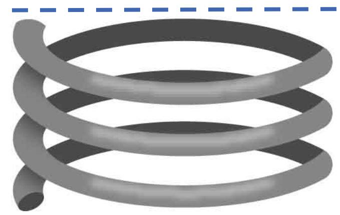
How safe is your bridge?

As you load a bridge, it deflects, or bends, then fractures. The way a bridge deflects changes as the load increases, going through a few different phases. The phases are pictured below.



Some bridges will fracture more predictably than others. One bridge may fail just after its proportional limit, while another will undergo significant plastic deformation first. Safe bridges must be both strong and predictable.

You are going to collect data to see how predictable your bridge is!



Physicist Robert Hooke used math to model springs – he said that deflection is proportional to load. His model, called Hooke's Law, also works for bridges deforming elastically.

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DATA

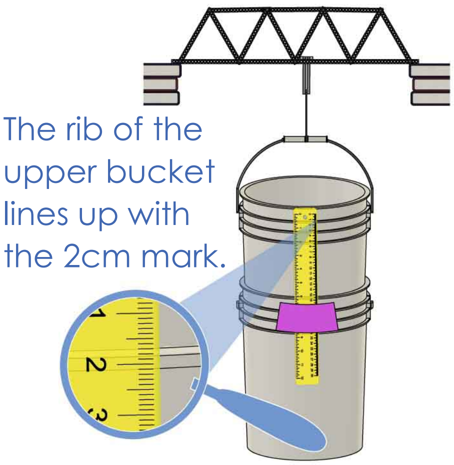
There's only one way to get data – you need to break your bridge!

Make sure you've built a testing station. See the **Testing Guide** for help.

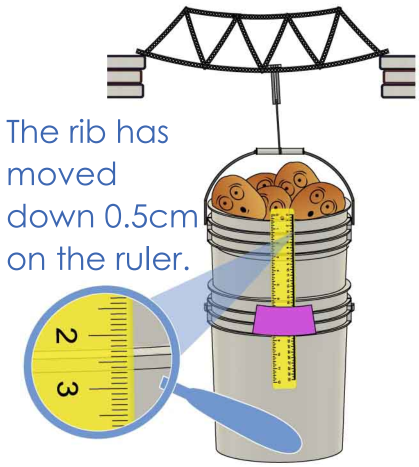
Documents available at **teachergeek.com/bridges**

1 Test your bridge to **get deflection data and record it** in the table below.

A **Set up** your bridge **and get** the **initial reading** on the ruler.



B **Add weight until** the upper **bucket drops 0.5cm** on the ruler.



C **Record the weight** in the table.

D **Note anything** you observe **that might affect your data,** like:

- Hook sliding
- Wires tightening
- Bridge twisting
- Bucket tilting
- Members breaking

E **Repeat until your bridge fractures!**

LOAD										
DEFLECTION	0.5cm	1.0cm	1.5cm	2.0cm	2.5cm	3.0cm	3.5cm	4.0cm	4.5cm	5.0cm

OBSERVATIONS:

If your bridge isn't broken, you need more data! Continue testing until your bridge breaks and record your data on an extra sheet of paper.

GRAPHICAL ANALYSIS

It's time to make your graph!

2 **Plot the data from your table** on the grid below. Be sure to label your axes and units.

3 Part of your graph should be linear, and part of it should not. **Draw a best fit line for the linear part and a best fit curve for the non-linear part**.

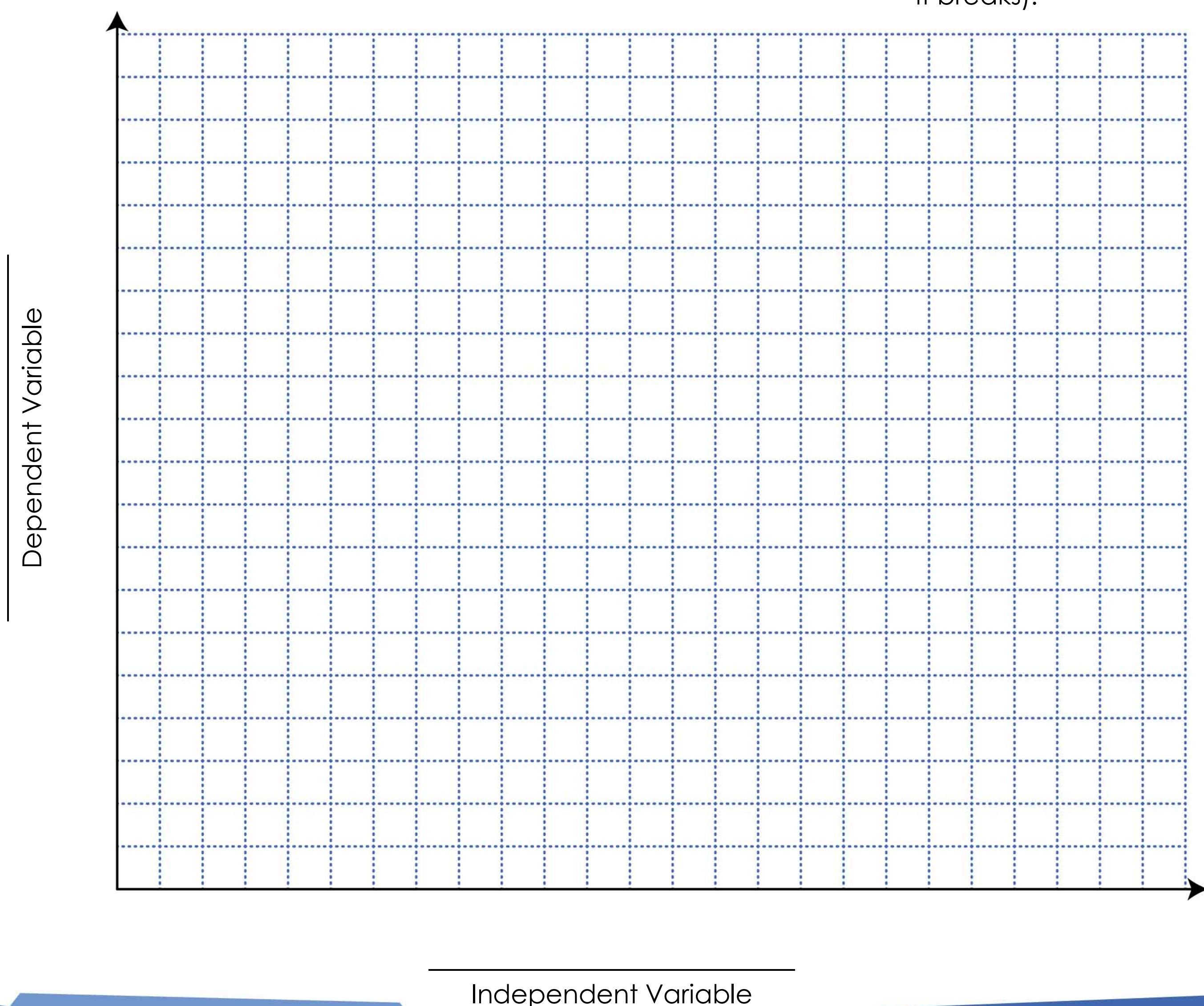
4 **Label the following features** on your graph. Some bridges will have plastic deformation so small that it won't appear on your graph.

Elastic Deformation
This is the linear part of your graph.

Proportional Limit
This is the point where your graph stops being linear.

Plastic Deformation
This is the non-linear part of your graph.

Fracture Point
This is the point where your bridge breaks (or the last point before it breaks).



CONCLUSION

What does your graph tell you about your bridge?

5 How well did your bridge show elastic and plastic deformation? Did you notice anything that may have affected your data? Reference your notes from Step 1.

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6 Brittle objects fracture with little plastic deformation. Ductile objects have a large amount of plastic deformation before fracture. Was your bridge brittle or ductile, and how does that make your bridge more/less safe?

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7 Using your data from testing, how could you improve your bridge? Be specific.

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ALGEBRAIC MODELS

Create a mathematical model using equations and inequalities!

8 What is the slope of your graph's best fit line? What does it tell you about your bridge?

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9 What is the y-intercept of your graph? What does it tell you about your bridge?

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10 Does your y-intercept make sense? Why or why not?

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11 Create an equation to model your bridge's elastic deformation.

$$y = \_\_\_\_\_x + \_\_\_\_\_$$

12 Fill in the inequality to show where the elastic region of your graph is.

$$\_\_\_\_\_ \leq x \leq \_\_\_\_\_$$

13 If your bridge had no proportional limit (deformation would always be elastic, never plastic), what load would cause your bridge to deflect exactly 12.3cm (4.84in.)? Show all work.

Mathematical models for two students' bridges are shown below. Mike's bridge is modeled by the graph, and Luanne's bridge is modeled by the equation. Use Mike's and Luanne's models to answer the questions below.

Luanne's Elastic Deformation Equation

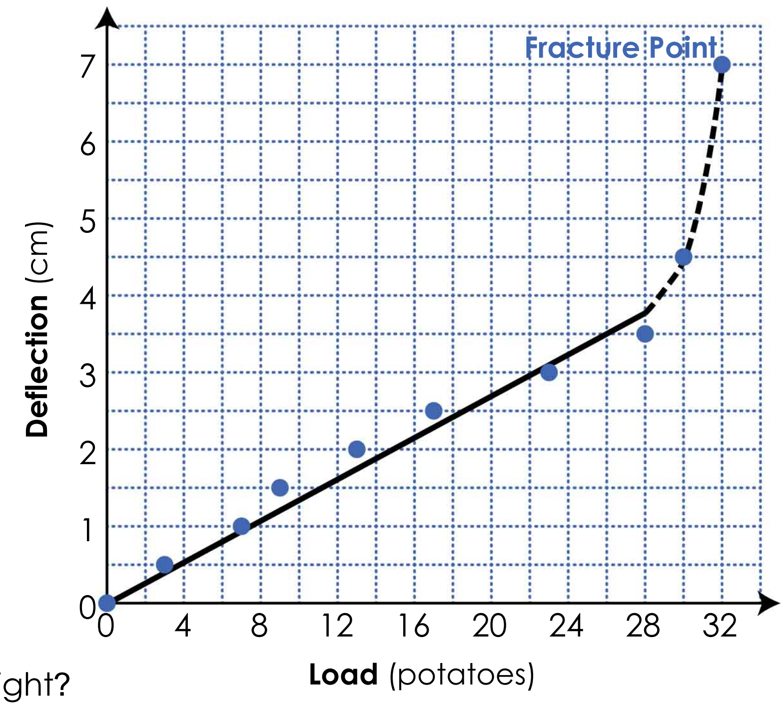
$$y = 0.15x$$

Where y is deflection (cm) and x is load (potatoes).

This equation applies when

$$0 \leq x \leq 32$$

Mike's Deflection vs Load



14 Whose bridge can hold more weight? Justify your answer and show all work.

15 Whose bridge is stiffer when both bridges are deforming elastically? Justify your answer and show all work.

16 Whose bridge is safer? Why?