

Name: \_\_\_\_\_

Section: \_\_\_\_\_

## Building Bridges to Engineering

Form groups of 3-4 members.

Make sure your group includes at least one person with *each* of the following skills:

- Experience with physics (free body diagrams)
- Comfort with trigonometry
- Solving systems by hand
- ***Neat Handwriting*** (recopy your work for your final draft).
- Writing a well reasoned response to a reading.

**Group Name:** \_\_\_\_\_

**Group Leader:** \_\_\_\_\_

**Members:**

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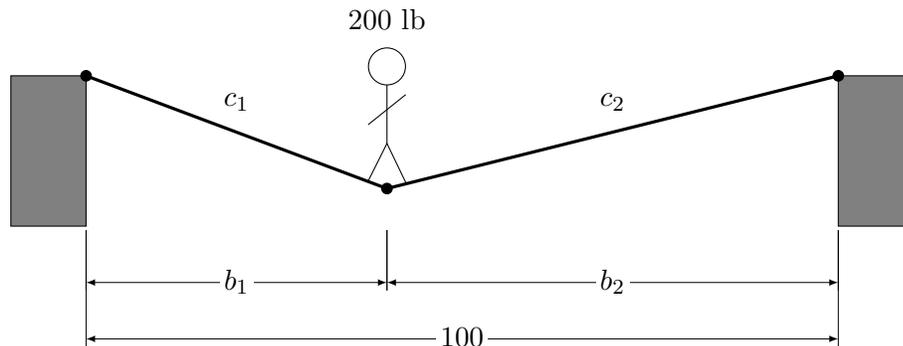
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**Instructions:**

- Carefully read and follow all instructions.
- Detailed notes on bridge analysis are posted at <http://mathlogic.org/stephenflood/math202>
- Write out your work and answers by hand on a separate piece of paper.  
Your writing and drawings should be *neat, organized, and complete*.
- You should also have a cover page, which lists your *group name*, the names of each *member* of the group, and the name of the group leader.
- You can find more information on the analysis of bridges in Chapters 12.1-12.6 of the book *Exploring Engineering* by Kosky et.al. You can find this book on reserve in the Library.
- **Ask me questions** after class, in office hours, and by email.

1. Suppose that you are using a *rope* bridge that is 120 feet long, to bridge a gap of 100ft. Suppose also that your weight is 200 lb.

As you walk across the bridge, the shape of the bridge changes, as do the forces exerted on each segment of the ropes (to your left and to your right).



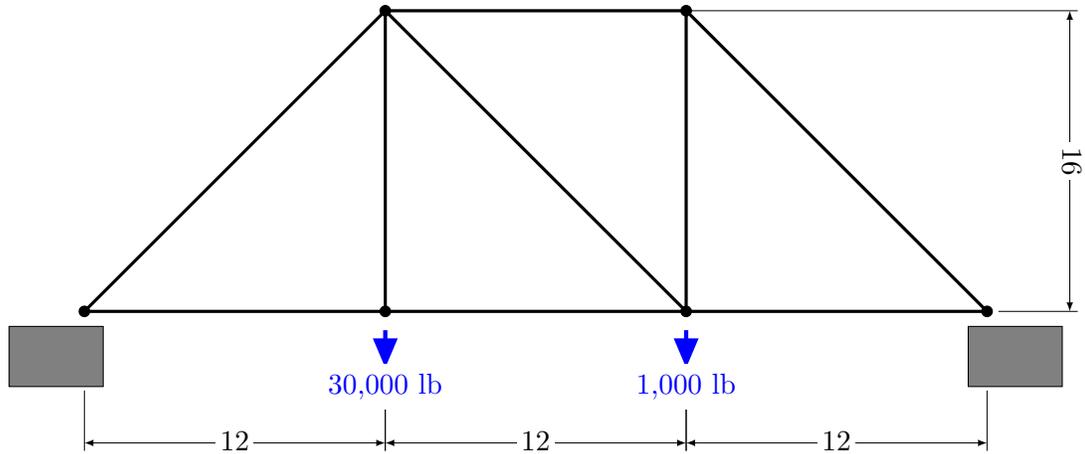
For each of the following stages of your journey,

- Sketch an accurate picture of the bridge.
  - Write down the free body diagram centered at the person (showing all three forces). Find and label all angles, giving one decimal place of accuracy.
  - Set up the system of equations. Use a scientific calculator and trigonometry to write all coefficients as decimals. Give four decimal places of accuracy.
  - Solve the system of equations by hand, using only a scientific calculator.
- (a) You have used 20 ft of the rope, and you are 2 ft from the west wall ( $b_1 = 2$  and  $c_1 = 20$ ).
  - (b) You have used 50 ft of the rope, and you are 38 ft from the west wall ( $b_1 = 38$ ,  $c_1 = 50$ ).
  - (c) You have used 60 ft of the rope, and you are 50 ft from the west wall ( $b_1 = 50$ ,  $c_1 = 60$ ).
  - (d) You have used 70 ft of the rope, and you are 62 ft from the west wall ( $b_1 = 62$ ,  $c_1 = 70$ ).

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2. You wish to study the forces exerted on the components of the following *rigid* bridge. For a rigid bridge, there should *not* be any motion or change of shape when force is applied.



- Draw the free body diagram for each joint. Find each angle using a calculator and trigonometry. Label each angle, giving one decimal place of accuracy.
  - Set up a system of equations for the forces on the bridge. Use a calculator and trigonometry to write all coefficients as decimals. Give four decimal places of accuracy.
  - Solve this system using technology. I recommend using the free Computer Algebra System *Sage*. Documentation for solving linear systems is on page 44-47 of [http://www.gregorybard.com/sage\\_for\\_undergraduates\\_color.pdf.zip](http://www.gregorybard.com/sage_for_undergraduates_color.pdf.zip)  
You can run these sage commands online at <http://sagecell.sagemath.org/>
  - Draw the bridge by hand, and label the force on each member of the bridge.
3. First, read the important and influential essay *The Unreasonable Effectiveness of Mathematics in the Natural Sciences* by the physicist Eugene Wigner.

Is the applicability of linear algebra to analyzing the forces on a bridge an example of the unexpected applicability of mathematics?

Explain and justify your answer in a short (2-5 paragraph) written response. To ensure you have a complete discussion, I recommend you follow the following procedure:

- Each member of the group should decide for themselves if this applicability is surprising or not, and should come up with their own explanation.
- All members of the group should share their answers and explanations. If you disagree on the answer or on the reason, talk about it.
- Come up with a consensus group position. If one or two members strongly disagree, they can write their own dissenting explanation.