Name: ______________________________________ Date: ___________________ Class: ____________________

Design a Truss Worksheet Example Answers

Design Challenge Problem Statement

Identify the need and constraints: Your engineering team has been tasked to create the strongest possible truss structure that will be used to design a bridge to cross one of our local rivers. Your objective is to design a truss that supports the weight of the vehicle traffic that will drive over the bridge. The truss must be sturdy and stable. You are also asked to design a truss that is abstract and unique; the clients do not want a truss structure simply made of plain triangles. You have been tasked to use different regular polygons in the construction of your truss designs.

Objectives

1. Build a unique and creative truss following the steps of the engineering design process.
2. Explain how the deformation of a shape affects the sum of its interior angles.
3. Explain why a triangle might be the strongest geometric shape.

Materials List

- graph paper
- protractors
- ruler
- pencils
- scissors
- 100 Popsicle sticks
- hot glue gun, hot glue sticks
- 6 stickers, to tag target angles

Requirements and Constraints

1. You must design a truss structure that is abstract and unique.
2. You must use combinations of 3 different polygons; 1 must be a triangle.
3. You may use up to 100 Popsicle sticks.
4. Your truss structure may not exceed 3 feet in length.
5. You must identify and tag 2 angles for each of the three polygon types used in your design, which you will measure and analyze throughout the design process.

Procedure

1. *Research the problem:* Read the problem statement and objectives.
2. As a team, choose 3 different polygons for your truss design. One must be a triangle. Choose from this list for the other two: square, pentagon, hexagon, heptagon, octagon, nonagon and decagon.

Our three selected polygons are: triangle, pentagon and square.

3. *Imagine: develop possible solutions:* Brainstorm ideas with your group for how you might want to construct your truss structure.
4. *Plan: select a promising solution:* Sketch your truss design, making sure to use all three chosen polygons to form the truss. You have 15 minutes to create your drawing on graph paper.
5. Find the sum of the interior angles in all of the polygons that you used to build your truss. Record the sums in the **Sum of Interior Angles** column on the data collection sheet.
6. Select 2 target angles in each polygon type; that means a total of 6 target angles. Mark these target angles on your truss drawing.
7. Get your truss design and angle measurements approved by the teacher.

Design approval by teacher: ✓ MHF

8. *Create: build a prototype:* Get your materials and start building your truss!

9. After the truss is built, use a protractor to accurately measure 6 target angles. Record your measurements in the **Measure of Angle 1** and **Measure of Angle 2** columns of your data collection sheet. Tag each target angle with a numbered sticker.

10. Make predictions for how you think your truss will perform during testing under a load:
    How much weight (in books) will your truss be able to hold?
    How much deflection will your target angles undergo?

    Predictions: Load: __3__ books Deflection: __20__ degrees

11. *Test and evaluate prototype:* Next, test your truss's load capacity. Take your truss to the test area and place textbooks of equal size on top of your truss—one at a time. Apply load until the truss experiences deformation of the target angles.

12. Use a protractor to measure the angles of deflection of your target angles. Record the results in the **Deflection of Angle 1** and the **Deflection of Angle 2** columns on the data collection sheet.

    Tip: How to determine the deflection angle? You have the initial measurements of the target angles. Once you apply load to your truss, the target angles change. *Calculate the change* between the initial target angle and the deformed angle. The change is called the deflection angle.

13. Record the number of books your truss was able to support before angle deformation.

    Our first truss design supported __2__ books.

14. Analyze your results by creating two graphs on your data collection sheet.

15. Before moving on to the "Redesign" part, communicate with your team and ensure that you all are on the same page with your results. Take some time to discuss and reflect on what you all discovered.

16. *Improve: redesign as needed.* The first attempt at a new design is rarely considered final. Engineers learn from their initial and subsequent prototypes and testing results, including failures. They look at why things don't work and work to make them better. Each revised effort is called an *iteration*.

    What are you and your team planning to change from your first design?
    List the changes that you will implement in the second iteration of your truss.

    Example answer: Our plan is to add some structural members to strengthen the squares; which deflected the most of the three polygon shapes. We will add structural support to the polygon near angle 1, where the most deflection occurred. We will also add a structural member to the triangle near angle 2, where the most deflection occurred for that polygon shape.

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17. *Iteration 1: rebuild and retest:* You have 15 minutes to modify/refine your initial truss design with the changes you listed above. Then test its strength by applying books to the top until the truss experiences deformation or failure. Record your new results.

Our second truss design supported ___3___ books.

18. Reflect on your results as you answer the questions below.

A. In the second iteration of your truss design, approximately how much load did the truss hold and how many Popsicle sticks did you end up using?

Example answer: It held 3 books! We used about 70 Popsicle sticks.

B. Engineers often adapt their original plans as they are prototyping and testing new product designs. Why might they need to do that?

Example answers: They run out of materials, run into time constraints, need to hold more load than originally anticipated, discover flaws in the original design, discover better ways to design sub-components, find better materials, find out that the original design needs to be stronger, etc.

C. Which polygon shape was best for truss design? What evidence did you collect that helped you determine this?

Example answer: The triangle was the strongest shape of the three polygons we used. Our evidence was the measured deflection angle for each polygon. The graphs visualized the data so we could see that the triangle had little deflection compared to the square. The number of books (the weight/load) also provided some evidence to support this conclusion, and this data was a more relatable test of strength to report to the clients, compared to the potentially confusing data on angle measurements.