Name _____

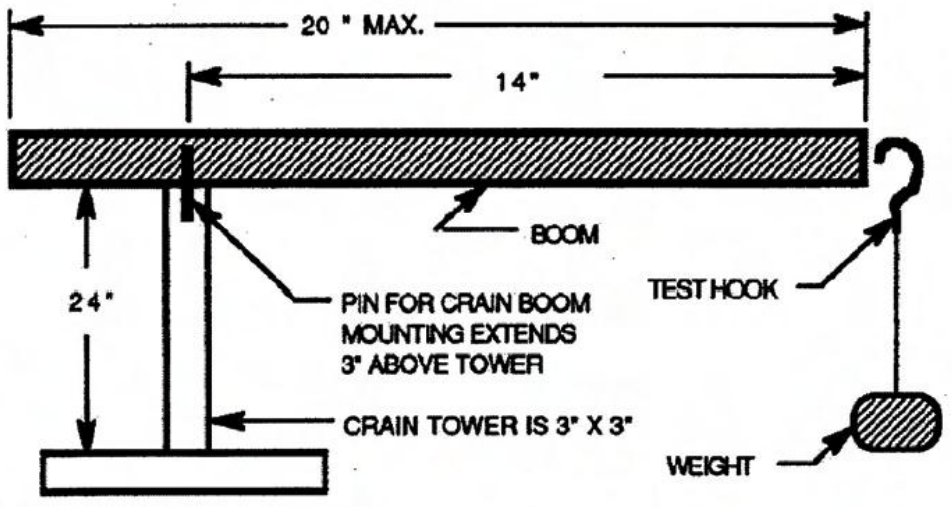
Unit 3: Design
Lesson 2: Design Process
File 3.2.4: Crane Strain Design Brief

Background Cranes are used in construction to assist in lifting heavy members by suspending them in the air while they are positioned and lowered into place. The loading capacity of a crane relates to how the crane was designed and built, in addition to how often it is used. The thickness and weight of the materials used to build the crane contribute to the load capacity. The number of times a crane can operate before failure is based on the type of loading, the construction of the materials used to build the crane, the mechanical design, and the overall condition of the crane.

Design Problem
You have been hired by Heck Construction to design and build a new crane for a new commercial construction project set to begin in the spring. Your team must design and construct a crane that will hold the greatest weight before failing.

Specifications
1. The crane boom must attach to the tower provided.
2. A one-quarter inch (1/4") hole will be used to mount the boom to the tower.
3. All joints must be glued (no mechanical fasteners).
4. You may not touch the tower or the boom during testing.
5. The boom must hold a weight fourteen inches (14") from the tower center.
6. The maximum length of the boom is twenty inches (20").
7. A mechanism must be provided at the end of the boom for attaching a hook for holding the test weights.
8. The boom must be the structure which holds the weight, not the testing device.

Materials
- Four (4) wood strips (⅛" x1/4" x 24")
- One piece of wood (3" x 3" x ¼")
- Seven (7) feet of mason string
- Fifteen (15) craft sticks
- Glue



Deliverables
1. **Each student** must complete an Engineering Design Folio documenting the engineering design process.
2. **Each team** must submit a prototype of the crane and conduct testing of the prototype.
3. **Each student** must submit the Crane Efficiency Worksheet.

Category	Below Average	Average	Excellent
Defining a Problem	Response shows only a superficial understanding of the problem **OR** rephrases the problem with limited clarity.	Response shows an understanding of the basic problem **AND** rephrases the problem clearly and accurately.	Response shows excellent insight to the problem **AND** rephrases it clearly, accurately and with precise detail.
Brainstorming	Contributes only 1 plausible idea sketch **OR** contributes implausible ideas.	Contributes 2 different oblique or isometric sketches of plausible ideas.	Contributes 3 or more different oblique or isometric sketches of plausible ideas.
Identifying Criteria / Constraints	Restates few given or implied criteria and constraints **OR** Fails to identify criteria **OR** fails to identify constraints.	Restates the given criteria and constraints clearly and accurately.	Restates all given and implied criteria and constraints accurately and precisely.
Researching and Generating ideas	Research was marginally relevant **OR** is not cited. Contributes ideas, but not based on research. **OR** produces inaccurate or incomplete sketches. **OR** no dimensions on the sketches are labeled.	Research was relevant to the challenge **and** is cited appropriately. Student contributes at least 1 plausible idea based on documented research **AND** produces marginally accurate sketches of design concepts. Some, but not all, dimensions may be missing.	Research was highly relevant to the challenge **and** is cited appropriately. Student contributes many plausible ideas based on research **AND** includes accurately labeled sketches of at least 3 designs.
Exploring Possibilities	Does not analyze solution(s) with respect to the criteria and constraints **OR** only analyzes 1 possible solution with respect to the criteria and constraints.	Satisfactorily analyzes at least 2 possible solutions with respect to the criteria and constraints.	Thoroughly analyzes at least 3 possible solutions with respect to the criteria and constraints.
Selecting an Approach	Student fails to justify the selection with reference to criteria and constraints.	Student justifies a selection with reference to some criteria and constraints.	Student justifies a logical selection with reference to the analysis of many criteria and constraints
Developing a Design Proposal	Design proposal is inadequate and lacking pertinent information. **OR** orthographic drawing is not labeled or is inaccurate, or missing. **OR** There are more than 4 spelling / grammatical errors per page.	Design proposal meets most requirements for all the elements **OR** meets all requirements for most elements **AND** has no more than 4 spelling / grammatical errors per page. Orthographic drawing is neat, labeled and accurate.	Design proposal includes all elements and meets all requirements with no more than 2 spelling / grammatical errors per page. Orthographic drawing is neat, labeled and accurate.
Making a Model or Prototype	Prototype does not meet all the task criteria **and/or** does not stay within the stated constraints.	Prototype meets all the task criteria and stays within the constraints.	Prototype meets all task criteria in insightful ways, reflecting knowledge gained from research **AND** stays within the stated constraints.
Testing and Evaluating the Design	Results of the testing are not recorded accurately.	Results of the testing are accurately recorded.	Events and observations during testing and results of the testing are thoroughly and accurately recorded.
Refining the Design – Data Comparison Graphs	The data set and graphics represent only one of the comparisons **OR** are not labeled **OR** show incorrect data **OR** the data is displayed in an inappropriate graph type.	The data set and graphics represented at least 2 comparisons and are labeled and show correct data. Data is displayed in an appropriate graph type.	The data set and graphics represented all 3 comparisons and are accurately labeled and show correct data. Data is displayed in an appropriate graph type.
Refining the Design – Redesign Explanation	Refinement and/or conclusions are not supported using the data **OR** Recommendations are not written clearly enough to understand their meaning. **OR** Minimal effort put forth to produce a data set.	Recommendations for refinements are supported by the interpretation of class data. The data is prepared and supported in a logical and sequential manor.	Explicit recommendations for significant improvement supported through the successful interpreting of class data through logical conclusions and observations. The data is presented in a logical and sequential manor.
Creating or Making it (performance)	Finished solution (product) fails to meet specifications. (efficiency is in the bottom 20%)	Finished solution (product) meets specifications. (efficiency is in the middle 60%)	Finished solution product) exceeds specifications. (efficiency is in the top 20%)
Communicating Processes and Results	Summary is not presented clearly or is inaccurate, showing a poor understanding of truss design. **OR** statements are not supported by data and research.	Summary identifies the point of failure and why and shows an understanding of truss design. All statements are supported by data and documented research.	Summary clearly and precisely identifies the point of failure and why and shows an excellent understanding of truss design. All statements are supported by data and research.

Engineering Design Process Folio – Crane Strain

Your Name		Group #	
Other group member's names			

1. **Define the Problem**
   What need or want must be met by the solution?

2. **Brainstorming**
   - On graph paper, make oblique or isometric sketches of <u>at least three</u> possible solutions that might meet the criteria and constraints of the design challenge.
   - Label them "BRAINSTORM IDEAS" and attach them to this document.

3. **Identifying criteria and specifying constraints**
   What are the criteria and constraints of the design problem?

Criteria	**Constraints**

4. **Research and Generating Ideas**
   <u>Research</u>
   - Research 4 different types of truss structures: Warren Truss, Pratt Truss, Howe Truss and the K Truss.
   - Find information about how they transfer the load (weight) and the tension (pull), their advantages and disadvantages.
   - In a word document, collect information you find during your research about truss structures.
   - Include a picture of each type.
   - Be sure to include proper citations at the end of your notes from each source.
   - Save, print and attach your notes to this paper.

   <u>Generating Ideas -</u>
   - Revise your brainstormed ideas to reflect what you learned about truss structures from your research.
   - On graph paper, make **new** isometric or oblique **drawings** that reflect your learning. These should be neat, with dimensions labeled.
   - Label them as "GENERATED IDEAS" and attach them to this document.

5. Exploring possibilities

Reflect on your design ideas and research notes and explain the structure used for each of your designs. Based on what you learned about truss structures in your research, explain the advantages and disadvantages of the particular structure used for each of your designs.

Design #	Structure used	Advantages/Disadvantages

In a Word document, create a chart like the one below to help you evaluate your designs.

a. Enter the constraints and criteria of the project in the first column. (you'll have to add rows to your chart)
b. Indicate how well each idea meets the criteria and constraints using the following point system: 2 pts = easily meets, 1 pt = somewhat meets, 0 pts = does not meet.
c. Total the columns and circle the highest score to indicate your BEST design idea as it is related to the criteria and constraints.

Criteria and Constraints	*Idea #1*	*Idea #2*	*Idea #3*
List one criteria			
or constraint			
in each row			

Add more rows if necessary *Add more columns if needed →.*

d. **Repeat this process** for the team designs. Each member of the group brings his/her best design to the team. All designs are evaluated again by the team and the points tallied up. Attach copies of the two charts to this document. Be sure to label which is yours and which belongs to the team.

6. **Selecting an Approach**
   Explain which design your team has chosen to build (student's name and design idea # from the team chart above) and justify it using evidence from your analysis of the criteria and constraints. Based on your research/learning about structures, explain what makes this design structure superior.

7. **Developing a Design Proposal**
   Create a design proposal (ONE per team) that includes the following: (NOTE: all members are responsible for making sure that all requirements for this step are met)
   - ***Title page:*** A separate cover page that includes your name, your team number and "Crane Strain Design Challenge". Leave space for a hand-drawn isometric drawing of the chosen design. Or use Google Sketchup to create a 3D picture of your team design.
   - ***Description of the problem***: Clearly state the problem you are trying to solve.
   - ***Selected Design Description***: Clearly describe and justify the design selection your team has made **and** make an orthographic drawing of the design on graph paper that will be attached to your proposal.
   - ***Materials List and Budget*:** make a chart that lists in the left column all the materials required to build your team's design and indicate the cost of the materials in the right column. Do not forget to include the cost of labor for the 3 of you to build it. ($7.25 / hour per person) Include a total cost at the end.
   - ***Timeline for building:*** Make a list of all the steps necessary to build and test your team's design and determine a deadline for each step.

8. Making a model or prototype

In the space below, document (using digital pictures) your construction of the model/prototype. Be sure to include a picture of the final model/prototype.

Construction in-process	Final Product

9. Testing and Evaluating the Design, using specifications.

When your design is complete you will present your design to the teacher. Measure the boom length (in.) Weigh the boom and record the weight below. Then hang the bucket on your crane using the 'S' hook. Add nails to the bucket until the crane boom breaks. Weigh the bucket of nails and record the weight. List the type of truss you used. Complete the efficiency calculations. Collect the data from all the teams.

Team #	Boom length (in)	Boom mass (g)	Load weight (lb)	Type of truss	Efficiency #

- Using Excel and your class data for the Crane Strain activity, create graphs that depict the relationship between:
    - boom length and efficiency (Graph #1)
    - boom weight and efficiency (Graph #2)
    - boom type and efficiency (Graph #3)

  Attach your graphs to this packet.

10. Refining the Design

Based on your graphs, make recommendations to redesign your crane, assuming you were to rebuild it. All recommendations must be supported by data and evidenced within your data set.

11. Creating or Making It – We will not be making another boom

12. Communicating processes and results

Write a summary paragraph that discusses the results of your testing, discussing which part of your design failed and why it failed. Use what you learned from your research and the data you collected to help you explain and justify your conclusion.