CHARLESTON
Charter School for Math and Science
CCSMS

Mr. Wolfrey – Physics

Name:_____ Date:_____

Group Members: _____

Bridge to Nowhere Project

Objectives:

- Use Newton's Laws in designing a bridge by using free body diagrams and Hooke's law to choose an appropriate bridge design and material for the project.
- Use engineering skills to build and test a bridge.
- Learn about different kinds of bridges by doing research and experiments.
- Draw free body diagrams of forces acting on the different kinds of bridges.
- Test different materials to find an appropriate on to use for the construction of their bridge.
- Build an appropriate bridge for the parameters.

Purpose:

Lesson focuses on how bridges are engineered to withstand weight, while being durable, and in some cases aesthetically pleasing. Students will work individually or in partners to design and construct a bridge that will support the greatest weight possible per gram of material used in construction. Students are encouraged to be frugal, and use the fewest number of popsicle sticks while still achieving their goals. Students then evaluate the effectiveness of their own bridge designs and those of other teams, and present their findings to the class.

Requirements:

- Bridge will hold 15 kg to a maximum of 22 kg (44 lbs)
- Use only popsicle sticks (4 ½ x 3/8) and standard grade school white glue.
- The bridge must be free standing. (with and without load)
  (*Do not use* tongue depressors, coffee stir sticks, or balsa wood).
- (No part of the bridge may hang over the edge of the testing tables for support.)

Overview:

Each team brings one bridge that will join a gap where the edges of the testing tables will be 22" apart. This means the bridge must be longer than 22".

The bridge must allow 4" of clearance for the middle 10" of the bridge. When the bridge sits on a desk, a 4" high stack of books should be able to move freely beneath the bridge <u>without making contact</u> with any part of your bridge. Imagine that there is an obstacle in the way that your bridge must go over.

A bar is placed across the roadbed perpendicular to the length at the point appearing to be the weakest on the structure (A bridge is only strongest at its weakest point!). Be sure you know what the loading device looks like before you build your bridge. Mass is added at a slow but steady rate until the bridge collapses or sags to 90% of its original height. At this point the total mass suspended by the bridge is recorded.

There is no limit to the amount of glue or number of Popsicle sticks (4 ½ x 3/8) that may be used. Remember, the heavier it is, the worse your strength to weight (S/W) ratio is. Try to build light and strong. Design is very important, so research, plan and test before building your final bridge.

Research:

Included in this project is a research report on topics related to bridges.

- Identify four different types of bridges and the pro and cons of each style. Identify three different types of forces a bridge encounters and how the design enables the bridge to handle those forces.
- Identify issues with bridges; including the process of building, the use of bridges, and lifespan.

- Briefly describe the three bridge incidents and why they happened.
- Include a sketch of your bridge and a description of key parts. Explain the strengths and weaknesses of your design and estimate how much you expect you bridge to hold.
- Identify the relationship of Newton's Laws to the project. Relationships should be made to the scaled version and full sized bridges.

The following should be identified and include any other relationships:

- Force due to gravity of each type of bridge, empty.
- What causes bridges to move and what law does this apply to?
- Does a bridge have an applied net force? What does this mean?
- What other forces are applied to the bridge? Following Newton's third law, what does this mean for the bridge?

Include the following terms in your project:

- Stress
- Strain
- Force
- Newton's Laws
- Equilibrium
- Weight
- Mass
- Gravity

Include visually the PLTW Design Process (Attached Below).

Score:

The real trick to building a great bridge is to build one that is very strong without consuming too many resources (time, money, materials, etc.). All bridges that can hold 1 kg in the bucket (a total of 2 kg) will be weighed and their corresponding Strength to Weight ratio will be calculated as follows:

Raw scores are directly proportional to the mass held by the bridge and inversely proportional to the mass of the bridge. Therefore the best scoring bridges are usually light but strong.

$$Raw\ Score = \frac{Mass\ held\ by\ bridge}{mass\ of\ bridge}$$

In order to create a fair and substantial delineation between each teams score, the raw scores are scaled so that they span the range from 20 to 100 points.

$$Final\ Score = 20 + 80\left(1 - \frac{RS_{max} - RS_{team}}{RS_{max} - RS_{min}}\right)$$

These projects will be ranked between groups! Thus each team is awarded between 20 and 100 points and rankings are competitively based on bridge mass and bridge strength. The team with the highest final score (100 points) wins.

Grading:

There are three grades for this project; the research, physics relationships and the bridge.

Scoring for bridge:

Fail	Bridge fails to meet all required criteria and therefore cannot be tested
D	Meets requirements, but cannot hold empty bucket
C	Strong enough to hold empty bucket (about 1 kg)
B	Bottom half of those qualifying for strength to weight ratio
A	Top half of those qualifying for strength to weight ratio

Five points will be added to Strength to Weight Raw Score for every 3kg over the 15kg goal. Student Strength to Weight ratios including bonuses will be listed on the board for all qualifying bridges.

Remaining Project:

Produce a poster that summarizes the project. On the project should include a minimum of the following:

- Project summary; including objective/purpose, materials, results, etc.
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- Background research identified above
- Physics relationships to model and other bridges listed above, including two Free Body Diagrams
- PLTW decision process
- Minimum of four pictures of bridges.

Poster Rubric **Points Received**	**Question and Problem** An appropriate problem and solution to the is clearly explained.	**Overview** Project is summarized correctly.	**Support** Background research that supports the solution is briefly explained.	**Physics** Physic relation is correctly explained.	**Project Visual** Materials are displayed in an organized and effective manner.
Exceeds Expectations 4					
Meets Expectations 3					
Approaches Expectations 2					
Does not meet expectations 1					
Did not attempt 0					
Total: 20 points					

Points are subject to being lost for poor effort or unappealing visuals. However, points may be earned for creative designs of bridge or other components!

Good luck and have fun!

PLTW Design Process

A <u>design process</u> is a systematic problem-solving strategy, with criteria and constraints, used to develop many possible solutions to solve or satisfy human needs or wants and to narrow down the possible solutions to one final choice. – ITEA *Standards for Technological Literacy*

1. **Define Problem**
   - Identify a problem
     - Validate the problem (*Who says it is a problem? Are there prior solutions?)*
     - Justify the problem (*Is the problem worth solving?)*
   - **If the problem is not valid or justifiable, the designer must define a new problem.**

2. **Generate Concepts**
   - Research
   - Brainstorm possible solutions
   - Consider additional design goals
   - Select an approach
   - **Scientific research may be necessary to pursue a solution for problems.**

3. **Develop a Solution**
   - Create detailed design solution
   - Justify the solution path
   - **If a solution is found to be invalid or cannot be justified, the designer must return to a previous step in the design process.**

4. **Construct and Test a Prototype**
   - Construct a testable prototype
     - Test prototype *(collect or analyze data)*
   - **If a prototype flaws, the designer must return to a previous step of the design process.**

5. **Evaluate the Solution**
   - Evaluate solution effectiveness
   - Reflect on design *(Recommend improvements)*
   - Optimize/Redesign the solution
   - **If the solution does not solve the problem, the designer must return to a previous step of the design process.**

6. **Present the Solution:**
   - Communicate the project