

NAME: \_\_\_\_\_

**SHAKE, RATTLE and ROLL**

**PART 1**

Our engineers continually strive to make buildings and their contents better able to resist the forces of earthquakes. After watching the video in the space below free write about:

- 1. Why you think some houses in earthquakes structurally remain intact, while others are destroyed?**
- 2. What are some problems that people living in earthquake-prone areas experience during earthquakes?**

National Geographic Earthquake Destruction  
[https://www.youtube.com/watch?v=4Y-62Ti5\\_6s](https://www.youtube.com/watch?v=4Y-62Ti5_6s)

**PART 2****Your Task**

Your structural engineering company designs and builds earthquake resistant buildings. Your engineering team must learn about the types of waves produced by earthquakes as well as the forces that may affect the stability of a structure. Using the links that follow, collect the information to help you design your earthquake proof building. Record your research findings and their sources in your engineering log (page \_\_\_ of this packet) for future reference. You may refer to them when all of the teams come together for a research meeting during our next class period.

**LINKS**

<http://legacy.mos.org/etf/force.html>

[http://www.iris.edu/hq/programs/education\\_and\\_outreach/animations/6](http://www.iris.edu/hq/programs/education_and_outreach/animations/6)

<http://www.safestronghome.com/earthquake/01.asp>

<http://www.iitk.ac.in/nicee/EQTips/EQTip09.pdf>

[http://www.iris.edu/hq/files/programs/education\\_and\\_outreach/aotm/6/SeismicWaveBehavior\\_Building.pdf](http://www.iris.edu/hq/files/programs/education_and_outreach/aotm/6/SeismicWaveBehavior_Building.pdf)

<http://www.geo.mtu.edu/UPSeis/waves.html>

<http://www.exploratorium.edu/faultline/activezone/index.html>

List the members of your design team here:

Once you have a basic understanding of the related concepts, using limited materials, your team will design, test, analyze, and revise a prototype earthquake resistant building model.

**PART 3**

**Investigate**

In this investigation, you will use a model to explore the effect of simulated seismic waves on your prototype structure.

**A Device for Producing Simulated Earthquake Waves:**

**Materials**

Plywood (1/8" thick) or heavy cardboard square (at least 40 cm on each edge)  
 foam upholstery cushion (approximately

1. **Construct** a model earthquake shaker table. Place 4 sponges or upholstery cushion on a table, to represent the interior of the earth. Place the piece of cardboard or plywood, which represents the Earth’s crust, on top of the sponge or cushion. This will enable you to simulate the motion caused by three types of earthquake waves.
2. As you have learned, seismic waves are vibrations that carry energy released from an earthquake through the earth. Earthquakes produce three different types of seismic waves: P wave or primary waves, S waves or secondary waves and surface waves. Create the different types of waves produced by an earthquake by moving the board on top of the sponge/cushion from side to side, up and down and with a rolling motion. Below fill in the table below to indicate type of earthquake wave that causes each motion. Turn and talk with your teammates to be sure you agree.

Motion	Type(s) of Seismic Wave
Side to Side	
Up and Down	
Rolling	

To learn more about how structures behave on the earthquake shaker table, each design team will focus on one of the common structural concerns in buildings found in seismically active areas. These include:

- Type of roof
- Open Spaces
- Unreinforced walls
- Type of Footing
- Height of Building
- Flexibility
- Useable Area
- Distribution of Load

Or your design team may determine a different structural concern to investigate with the approval of the teacher.

Your team must design a controlled experiment to investigate the effect of changing the selected structural concern. Meanwhile, other teams will be investigating other concerns. Each team will share its findings with the class at our next research meeting to better inform improvements to future prototype structures.

For this phase of development, the following building materials are available to all teams:

- Mini-marshmallows
- Coffee stirrers
- Index cards

Each team also has access to the following tools:

- Scissors
- Ruler

Each structure must securely support at least 10 pennies.

Building and testing time is limited to **20 minutes**.

As a team, complete the following information and submit it to your teacher. Your team will receive materials once your teacher has approved your plan.

What is the question your team is investigating?

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Your team will test several designs that differ in only one way, a way that relates to the structural concern you are investigating. Draw your plans below. Be sure give each structure a descriptive name and label the drawings.

Structure 1	Structure 2
Structure 3	Structure 4

Describe your experimental procedure:

What is your independent variable? (the variable you changed on purpose)

How do the two structures differ?

What is your dependent variable? (the variable you will measure)

How will you measure it?

What variables will you control? (keep the same so it will be a fair test)

Describe the resources you used to investigate the problem  
List the time, material, people, tools, equipment.

Conduct your experiment and record your data in a table in the space below. Design it to fit your experiment.  
Do the data seem reasonable? If not, do you need to repeat any trials to correct errors? What must be done to the data to make sense of it?

What were the results of your experiment?

What claim(s) can you make about the structural factor your team investigated?

What evidence from your experiment and your internet research supports your claim?



Discuss your findings with the rest of the class during the design group meeting. Use the space below to take notes on the findings of other groups. You will need this information when your team designs a prototype structure that meets the considers the constraints and meets the criteria your class determines during the discussion.

A large, empty rectangular box with a thin black border, intended for students to take notes on the findings of other groups during a design group meeting.

**PART 4**

**Criteria & Constraints for Final Structure – Design Team Notes**

Criteria	Constraints

**Criteria & Constraints for Final Structure – Company Consensus**

Criteria	Constraints

ENGINEERING LOG


Research Record      Design Team \_\_\_\_\_ Engineer \_\_\_\_\_

Record key ideas your group found on selected internet sites. Be sure to make a note of which sites support the ideas you have listed.

ENGINEERING LOG

Version 1    Design Team \_\_\_\_\_ Engineer \_\_\_\_\_

Initial Concept Sketch



Description and reasons for the design choices.



PREDICTION: \_\_\_\_\_

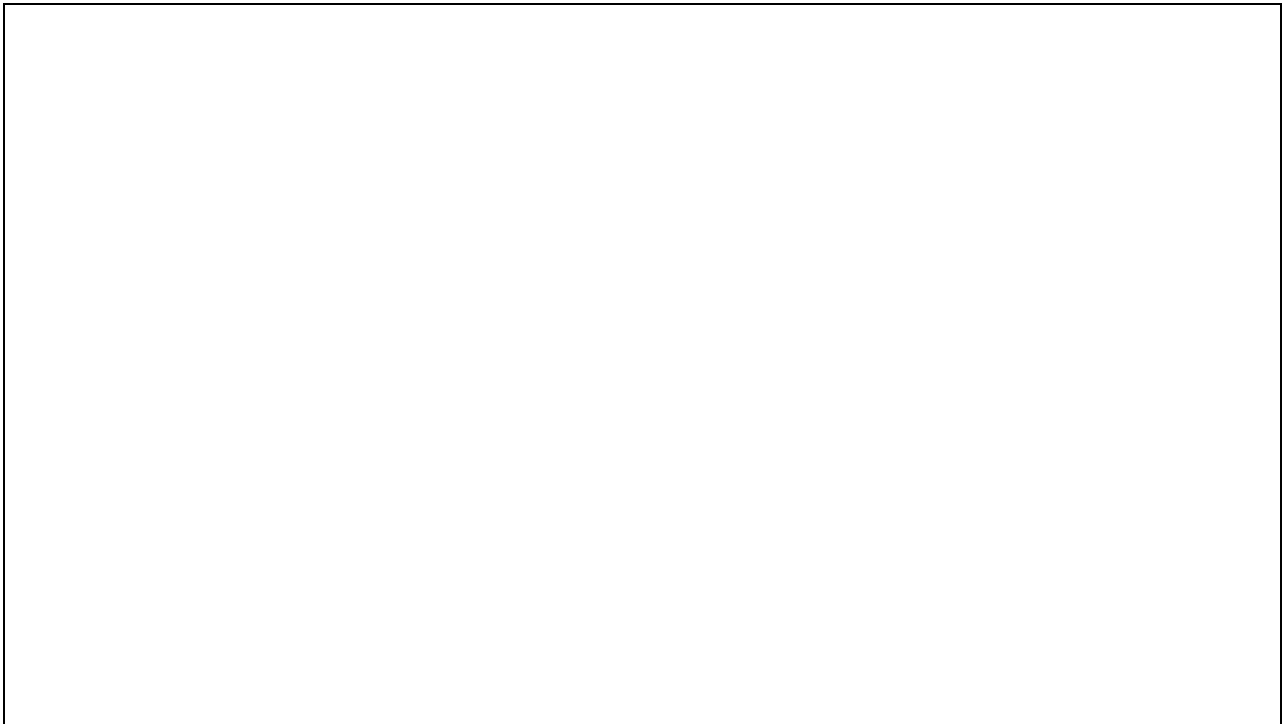
I predict this because:

Version 1    Design Team \_\_\_\_\_ Engineer \_\_\_\_\_

Testing Procedure:



Data and results:



Version 1    Design Team \_\_\_\_\_ Engineer \_\_\_\_\_

Did your design work the way you wanted it to? How do you know? Use your data to explain.


What cause and effect relationships are apparent from your testing of this version of the structure?

This is Version 1: You have two more chances to optimize your team's design.

ENGINEERING LOG

Version 2    Design Team \_\_\_\_\_ Engineer \_\_\_\_\_

Initial Concept Sketch



Description and reasons for the design choices.



PREDICTION: \_\_\_\_\_

I predict this because:

Version 2    Design Team \_\_\_\_\_ Engineer \_\_\_\_\_

Testing Procedure:

Data and results:



Version 2    Design Team \_\_\_\_\_ Engineer \_\_\_\_\_

Did your design work the way you wanted it to? How do you know? Use your data to explain.


What cause and effect relationships are apparent from your testing of this version of the structure?

This is Version 2: You have one more chance to optimize your teams' design.


ENGINEERING LOG

Version 3    Design Team \_\_\_\_\_ Engineer \_\_\_\_\_

Initial Concept Sketch



Description and reasons for the design choices.



PREDICTION: \_\_\_\_\_

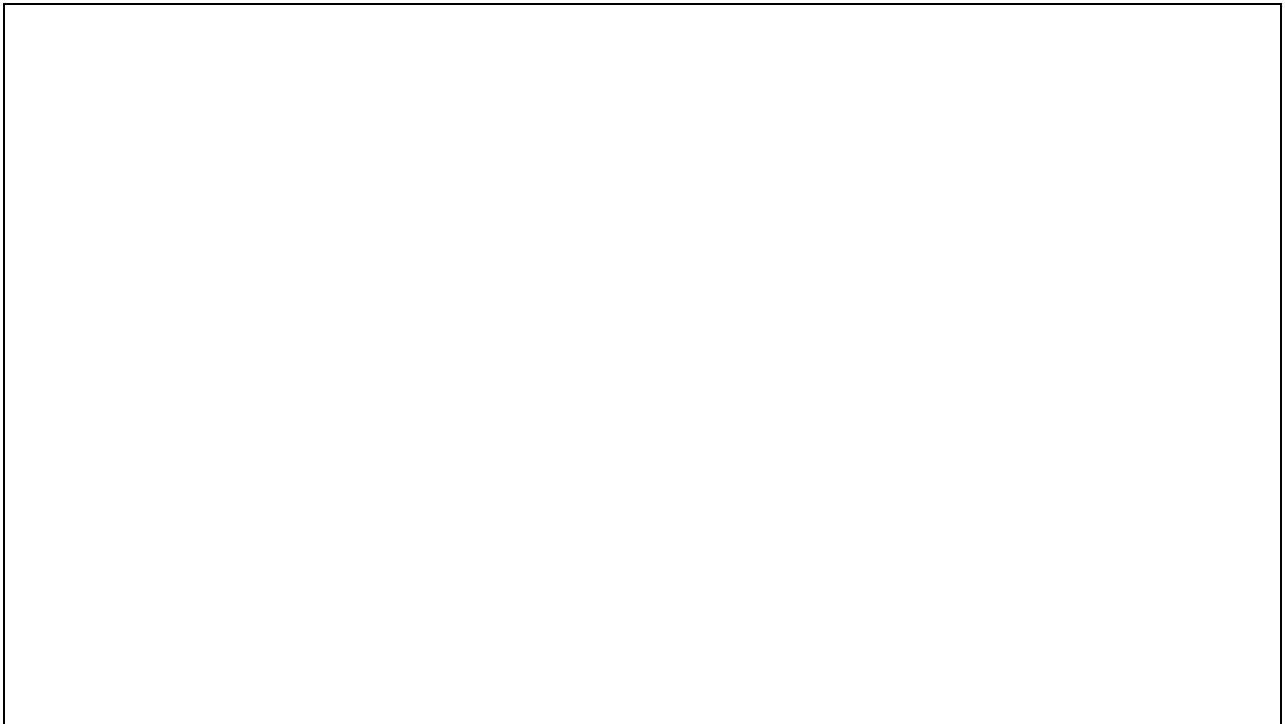
I predict this because:

Version 3    Design Team \_\_\_\_\_ Engineer \_\_\_\_\_

Testing Procedure:

A large, empty rectangular box with a thin black border, intended for students to write their testing procedure.

Data and results:

A large, empty rectangular box with a thin black border, intended for students to record their data and results.

Version 3    Design Team \_\_\_\_\_ Engineer \_\_\_\_\_

Did your design work the way you wanted it to? How do you know? Use your data to explain.

What cause and effect relationships are apparent from your testing of this version of the structure?

This is Version 3: Unless you get special permission and an extra set of engineering log pages, you are done making improvements. This is your team's final product.

**Rubric for the Evaluation of *Shake, Rattle, and Roll* Design Project**

NOTE: The criteria and constraints are to be arrived at by consensus of the class; the highlighted portions of the rubric should be modified accordingly. The ones below are samples.

	<b>3 (meets or exceeds expectations)</b>	<b>2 (mostly meets expectations)</b>	<b>1 (mostly does not meet expectations)</b>	<b>0 (not scorable)</b>
<b>1. Meet primary criteria.</b>	<p>The final structure withstands <b>10 or more seconds</b> of shaking, remaining in original position, with no damage</p> <p>AND</p> <p>The final structure is at least <b>30 cm</b> tall</p> <p>AND</p> <p>The final structure supports at least <b>10 pennies</b></p>	<p>The final structure withstands <b>3.0-9.9 seconds</b> of shaking</p> <p>AND</p> <p>The final structure is at least <b>30 cm</b> tall</p> <p>AND</p> <p>The final structure supports at least <b>10 pennies</b></p>	<p>The final structure collapses in fewer than <b>3.0 seconds</b></p> <p>OR</p> <p>The final structure is <b>&lt;30 cm</b> tall</p> <p>OR</p> <p>The final structure supports fewer than <b>10 pennies</b></p>	<p>No testable prototype completed</p>
<b>2. Stay within provided constraints.</b>	<p>The final structure is built of no more than <b>30</b> mini marshmallows, <b>50</b> toothpicks, <b>4</b> index cards</p> <p>AND</p> <p>The final structure is not touched during shaking</p>	<p>The final structure exceeds one constraint</p> <p>AND</p> <p>The final structure is not touched during shaking.</p>	<p>The final structure exceeds two constraints</p> <p>OR</p> <p>The final structure is touched during shaking</p>	<p>No testable prototype completed</p> <p>OR</p> <p>The final structure exceeds three constraints</p>
<b>3. Complete the Engineering Log with clear wording.</b>	<p>All parts of the Engineering Log filled out and clearly communicated</p>	<p>All parts of the Engineering Log filled out, but some parts have clarity issues</p>	<p>Parts of the Engineering Log are not filled out</p> <p>OR</p> <p>The majority of the Engineering Log has significant clarity issues.</p>	<p>No performance data collected</p>

<p><b>4.</b> Design the solution with research in mind.</p>	<p>Evidence is provided that shows that design choices are <b>directly</b> informed by research into earthquake-resistant buildings.</p>	<p>Evidence is provided that shows that design choices are <b>somewhat</b> informed by research into earthquake-resistant buildings.</p>	<p>Evidence is provided that shows that design choices are <b>minimally</b> informed by research into earthquake-resistant buildings.</p>	<p>No design choices made</p>
<p><b>5.</b> Develop and optimize the design solution based on performance data.</p>	<p>Evidence is provided that shows that development and optimization were <b>directly</b> informed by data from performance tests.</p>	<p>Evidence is provided that shows that development and optimization were <b>somewhat</b> informed by data from performance tests.</p>	<p>Evidence is provided that shows that development and optimization were <b>minimally</b> informed by data from performance tests.</p>	<p>No design solution made</p>