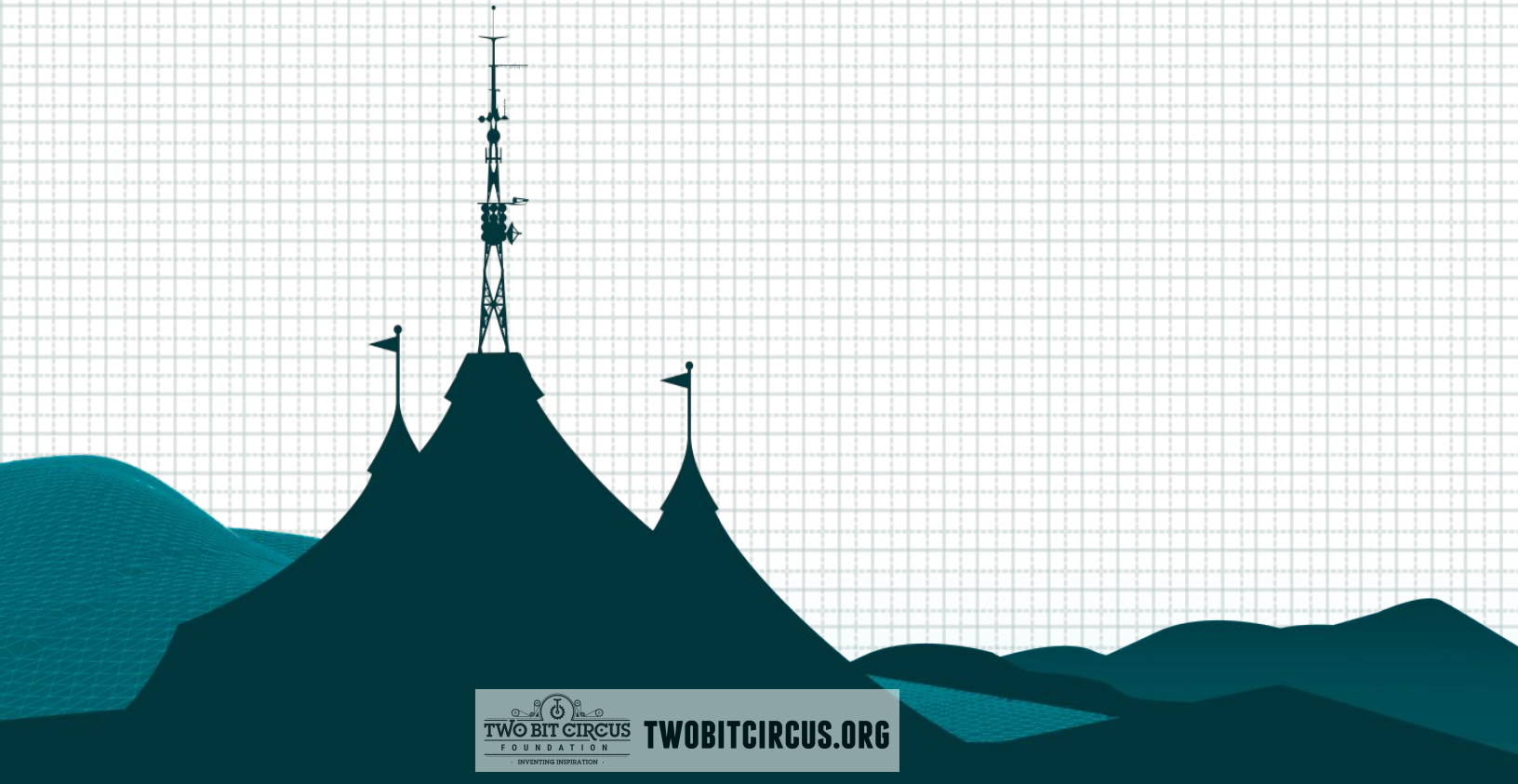
TWO BIT CIRCUS
FOUNDATION
· INVENTING INSPIRATION ·

ELEMENTARY SCHOOL
ENGINEERING TOWERS

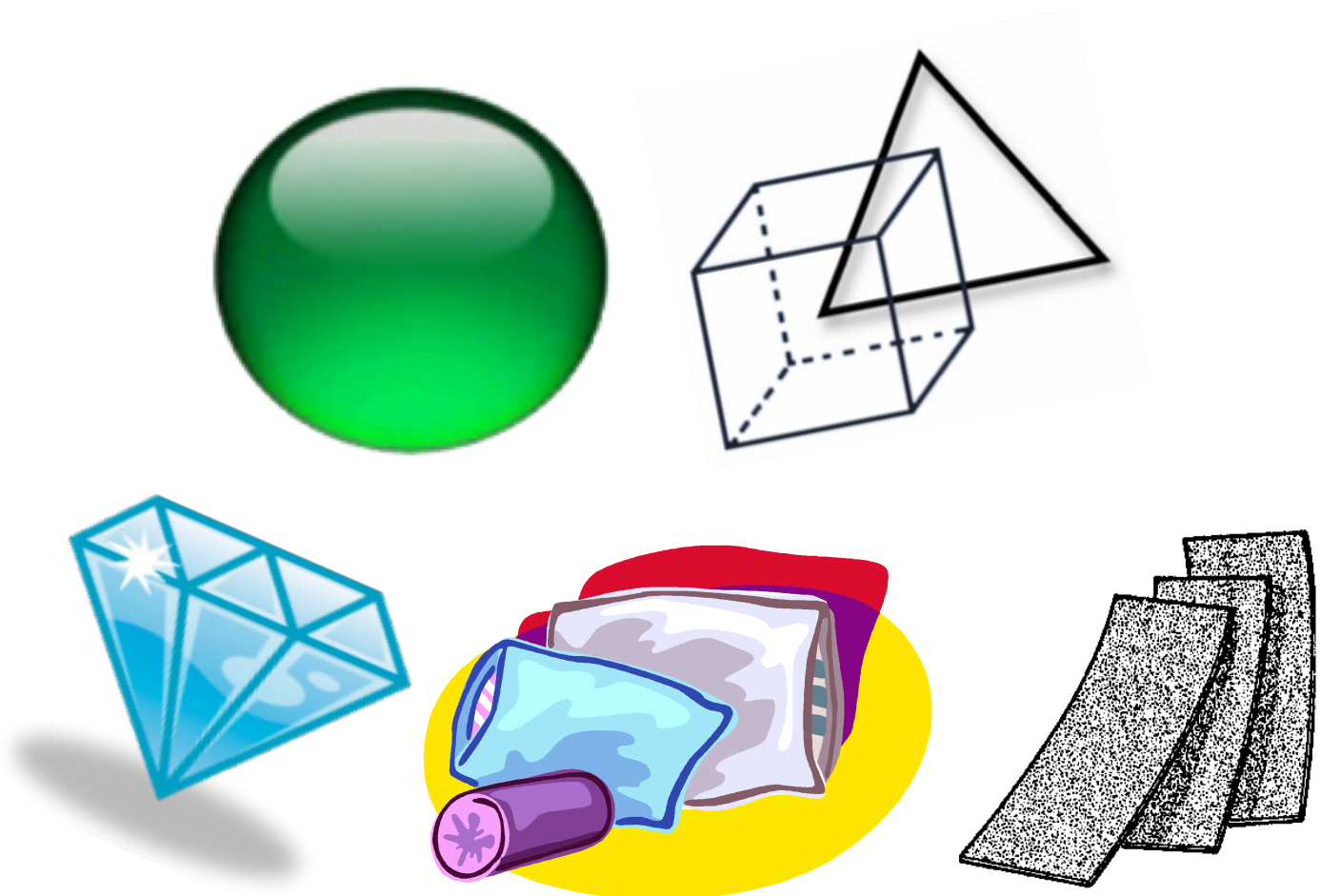
EDUCATOR CURRICULUM



Name _____

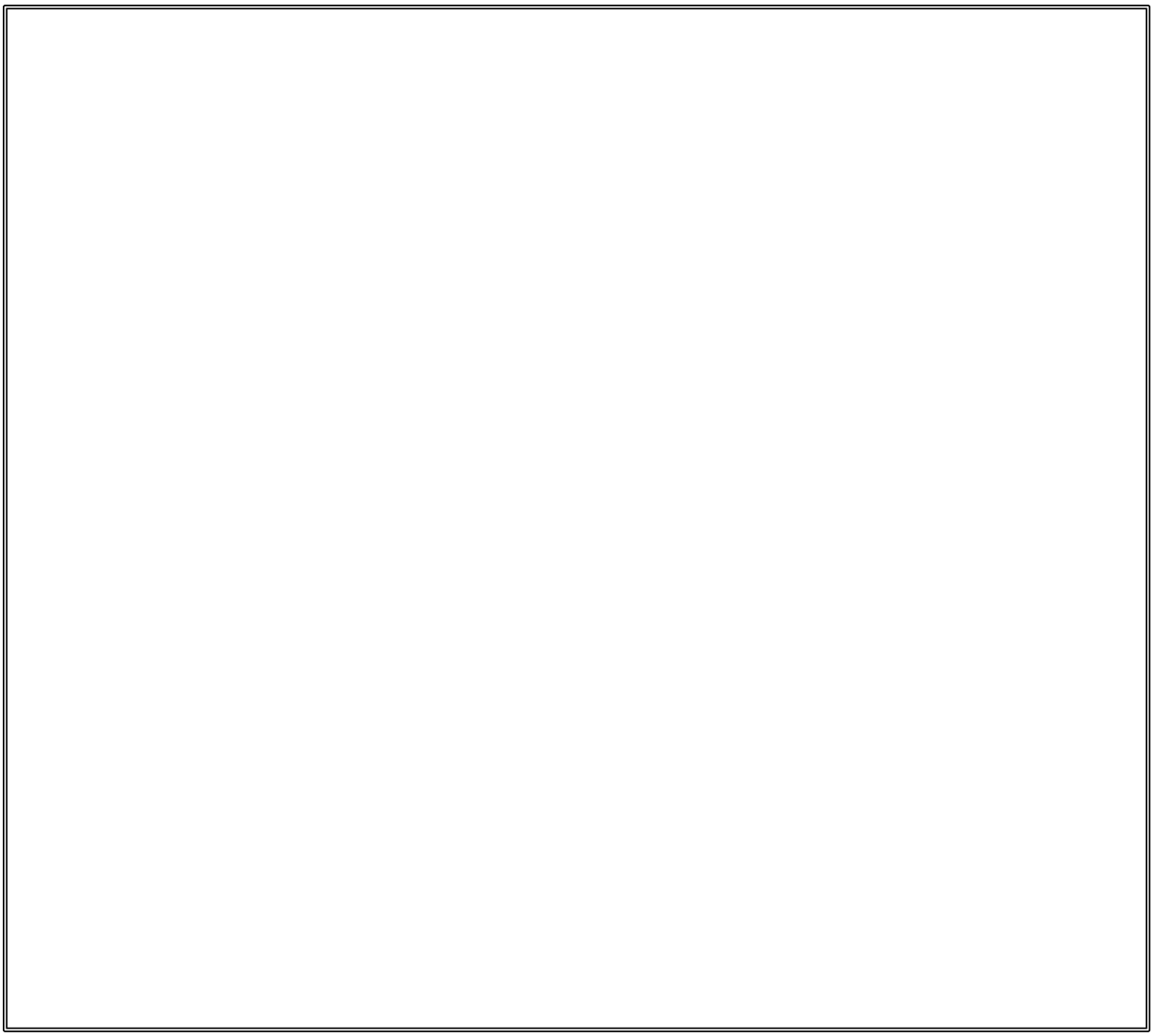
Building with Materials

Matter and Its Properties



Initial Tower Design

Draw a design of a tower. Include the types of materials and explain how you would arrange and connect them.



Why did you choose these materials for your tower?

Why did you arrange them this way?

Why did you connect them this way?

How does the understanding of the materials we have to work with help us design better solutions?

Use drawings words and numbers to explain your thinking.

El Pueblo: The Watts Towers

By Sam Simon

Project Description

A Community of Towers

Project Description:

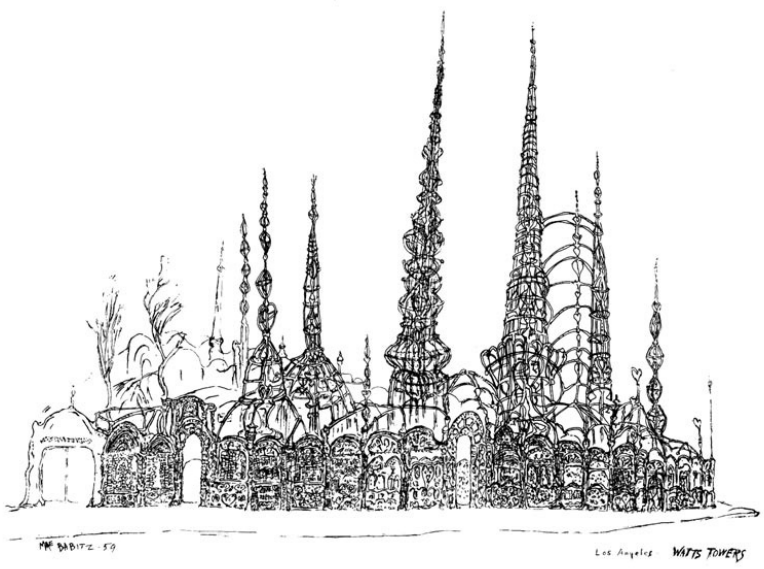
As an inquiry into the properties of different solid matter you and your team will work together to create a tower out of “trash.” After your tower is built, you and your team will present your work along with the commentary about what you learned as a team member, an artist, a scientist, and an engineer. As a culminating activity, all the towers will be arranged together to create a “pueblo” or “town” that represents your community.

You will need to work together collaboratively to

- Create a design of your tower
- Consider the structural integrity of your tower (how strong and stable it is)
- Consider the aesthetic impact (how it looks and how people respond to it)
- Plan the construction of your tower
- Build and test your tower to ensure that it can withstand an earthquake test
- Create and give a presentation about your work and learning process
- Reflect on your understanding of solid materials throughout this process

You will be evaluated on

- ❖ How you collaborate with your team
- ❖ The detail and completeness of your design
- ❖ Your project plan
- ❖ Your explanation of how and why you included certain elements in your design
- ❖ Your interactive notebook responses
- ❖ Your final presentation



CONSTRUCTION Criteria and Constraints

Structure	Materials	Connections
☐ Reach a minimum height of 3 Feet ☐ *Must fit a 1ft by 1ft platform ☐ *Must be able to be transported across the room ☐ Can have little or no visible evidence of stress after an earthquake test (torsion, shear, compression, bulge) ☐ Must be the structure depicted in written/drawn plan	☐ Incorporates a variety of materials ☐ *Materials are chosen based on their properties ☐ Must be made of T4T materials or found materials	☐ Uses at least 2 connection types ☐ *Cannot use tape or glue

DESIGN Criteria and Constraints

Plan	Drawing	Revision
☐ Must have an idea or feeling to be expressed ☐ Must create a design that expresses the focus idea or message ☐ Includes ideas or elements from all team members ☐ Considers the aesthetics and color of material type ☐ Considers how materials function and interact	☐ Must include all the component parts ☐ Must depict and label materials used ☐ Must depict how pieces will be connected ☐ Shows more than one perspective ☐ Has close ups of details ☐ Must include a rational for decisions	☐ Every change is depicted in the plan ☐ Changes are documented in different colors ☐ If necessary revisions are documented on new paper or overlaid with post-it/taped papers ☐ *cannot erase

Wonderings and Questions

How and why would understanding your materials help you build a better tower?

SCULPTING is the art of creating three-dimensional forms. The artists who create sculptures are called sculptors. Some processes include **removing** material (carving), **forming** material (casting or molding) or **assembling** materials (welding, gluing, or binding in some fashion).

Sculptures created using discarded materials and wires by Barbara Franc

STREAM OF CONSCIOUSNESS: Think as you draw. Think on the page, not in your mind.

DOODLE

How can we think differently about something?

Substitute

Combine

Adapt

Modify

Put to other uses

Eliminate

Rearrange

Why is it important to hold off on evaluation and allow ideas to grow and change?

How are structures made up of different smaller parts?

What did you learn about paper from creating your sculpture?

Mediums of Sculpture

rock

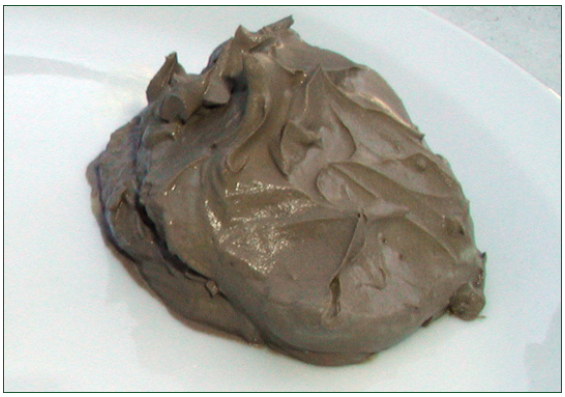
Strengths **Limitations**

wood

Strengths **Limitations**

metal

Strengths **Limitations**



clay

Strengths **Limitations**

Plastic

Strengths

Limitations

Paper

Strengths

Limitations

Yarn and Fabric

Strengths

Limitations

If you were to build your sculpture out of any material, what would it be and why?

If I were to build my own sculpture, I would use

_____ because _____

_____.

I might also use _____ because _____

_____.

What kinds of materials do you use in your everyday life?

How do you use them?

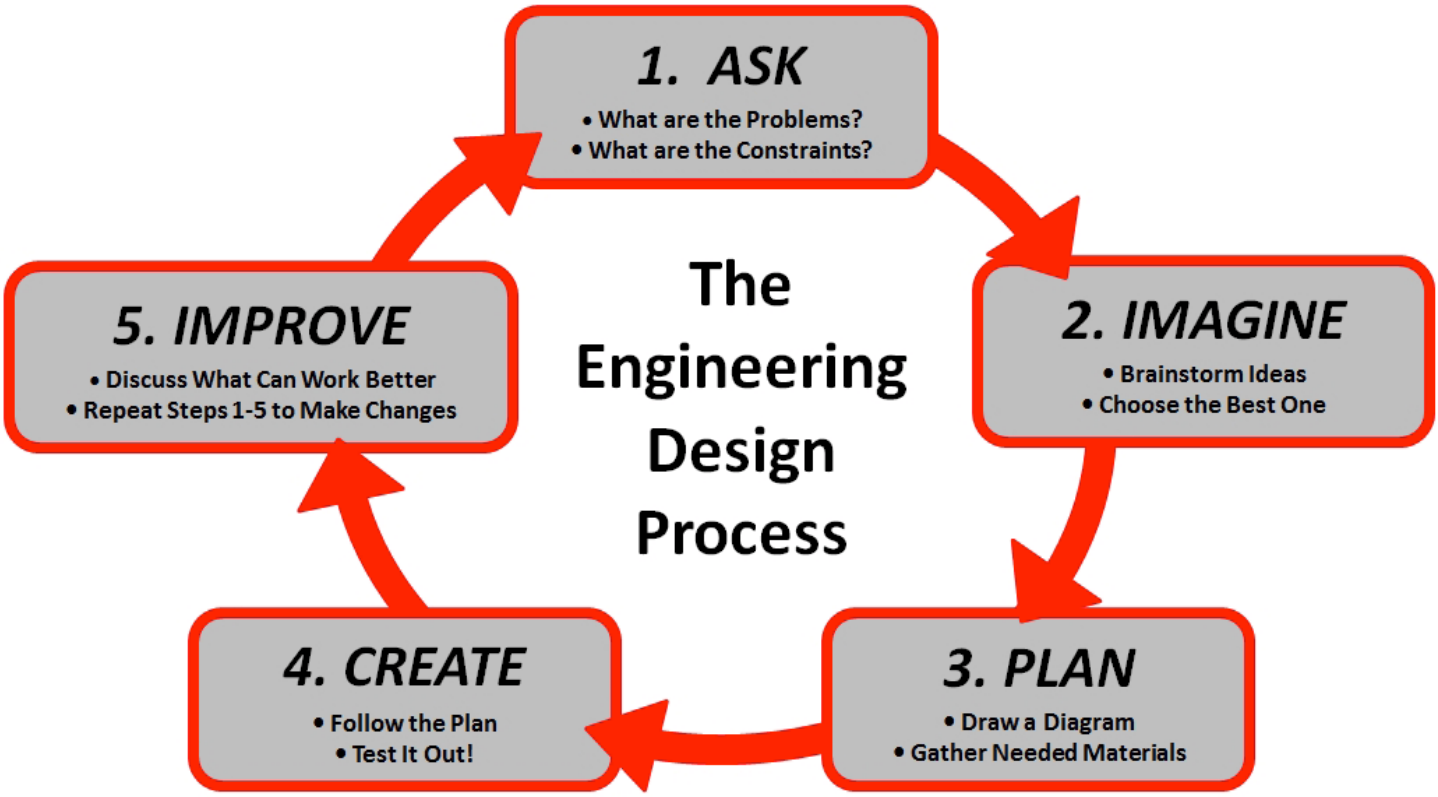
What do you know about these materials?

Artist	Artists attempt to understand the world and themselves in it through a creative process. They create works in a variety of mediums (painting, drawing, sculpture, photography, installations and performance art). They use a creative process that allows them to explore and express ideas and feelings. Artists envision their works and use engineering and knowledge of materials to bring their vision to reality.
Scientist	Scientists attempt to understand the natural world through objective observation and systematic investigation. Their system of learning is called the scientific method, where they create hypothesis and test them with experiment they design. Scientists create models and theories based on their findings that they continue to test and improve
Engineer	Engineers use their understanding of the world to solve problems. They study the problems they want to solve, imagine solutions, and then create and test designs that they revise until they solve their problems. Engineers design new materials, design structure and machines, and they design systems to produce things more efficiently

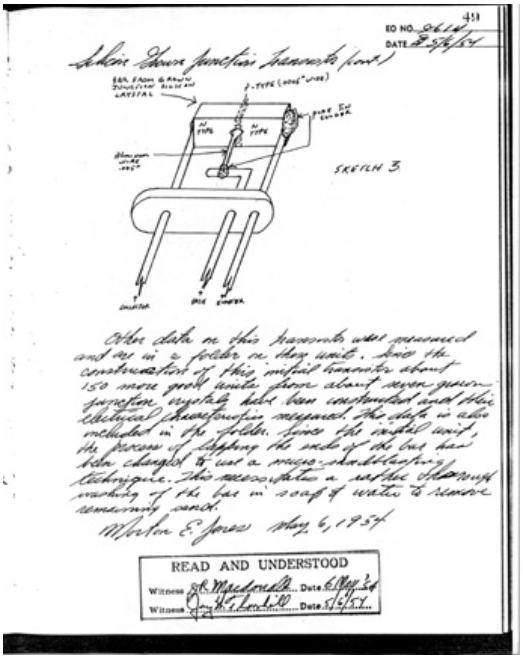
Lesson 4

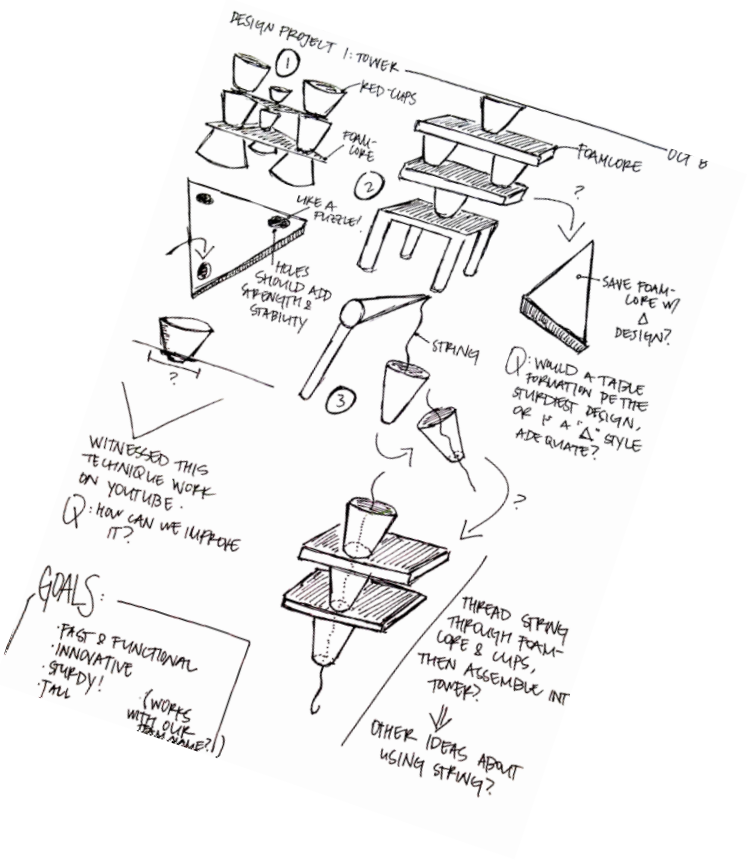
Why might it be important for a sculptor to think like a scientist at times?

Why might it be important for a scientist to think like an engineer at times?


1. ASK
• What are the Problems?
• What are the Constraints?
2. IMAGINE
• Brainstorm Ideas
• Choose the Best One
3. PLAN
• Draw a Diagram
• Gather Needed Materials
4. CREATE
• Follow the Plan
• Test It Out!
5. IMPROVE
• Discuss What Can Work Better
• Repeat Steps 1-5 to Make Changes
The Engineering Design Process

Engineering Log





As engineers work on projects they make lots of changes, so when there is a failure (or improvement), it may be difficult to determine the cause. There are so many possibilities, that without a log, it could take along time to run all the tests to identity the cause. Therefor logs should describe everything done, be organized with a date and time, and be in chronological order

Engineering Log Criteria

- Date
- Time
- Logs in chronological order
- Records of every change and action
- Notes of ongoing observations
- Documents of adjustments to techniques and methods
- Provide a space for questions and speculations
- Include drawings, numbers and words

Water Bottle Challenge

First Design Did it work? _____	Second Design Did it work? _____
Third Design Did it work? _____	Fourth Design Did it work? _____

What was something that you **imagined** in your design that didn't quite work the way you envisioned it?

What I imagined . . .	What actually happened . . .

What did you learn about the materials that you worked with?

Properties of Solids Sort

Rigid	Flexible	Hard
Soft	Rough	Smooth
Thick	Thin	Strong
Weak	Large	Small
Translucent	Opaque	_____

Rigid **Flexible**

Hard **Soft**

Rough **Smooth**

Large **Small**

Most sides **Least Sides**

Strong **Weak**

Thick **Thin**

Evaluate materials

Claim:

I believe to be best materials for building a tower is/are . . .

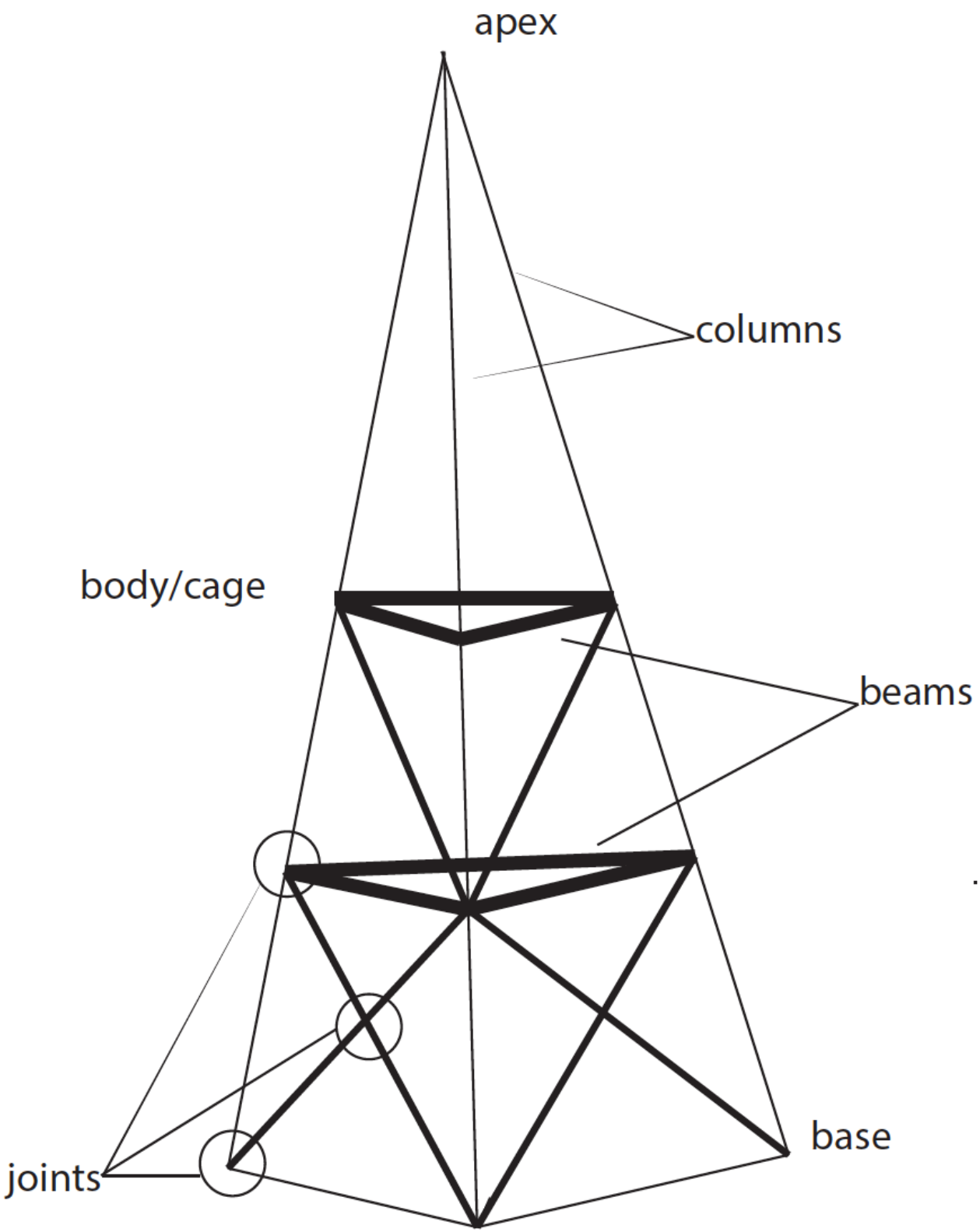
Evidence:

What observations of the materials support your claim?
What did you see?

Reasoning:

How would this property be good for building a structure?

Parts of a Tower

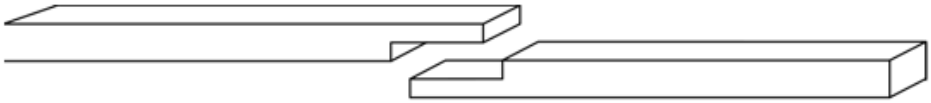


Which tower or towers caught your attention?

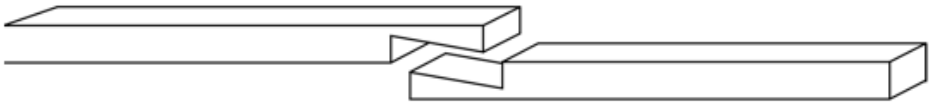
What are some tower features that inspired you?

Types of Joints

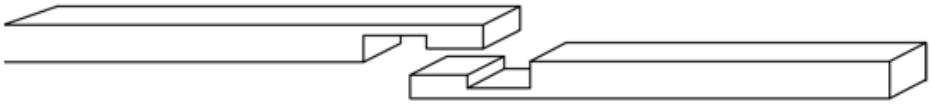
Splice joint- one piece is connected to another by way of cuts in both sides that cause them to overlap and interlock in some fashion.



Half Lap Splice



Bevel Lap Splice



Tabled Splice Joint

Butt joint- one piece flattens up against the other

Slip joint- one piece slips inside the other.

Coupling- a tube like piece that fits each piece within it to connect them together

Dowel – a short rod that connects one piece to the other by fitting inside of each

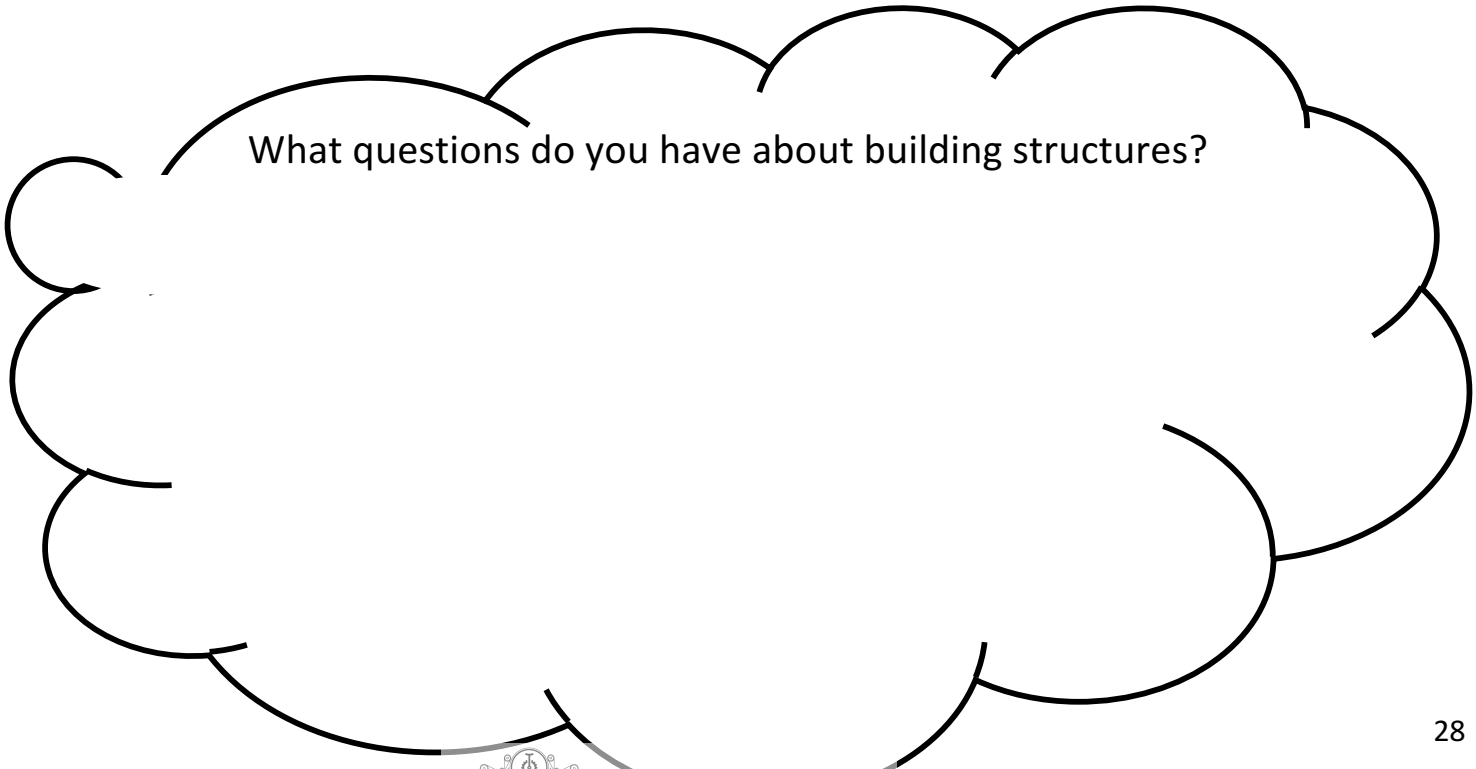
Tie down/fastener- a cord that can be wrapped around the joint to keep the pieces together.

Learning About Joints

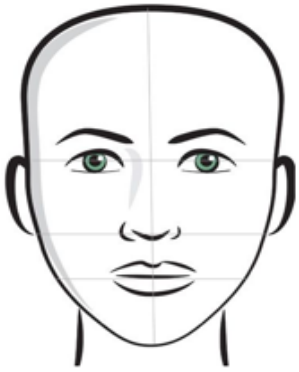
Type of joint	**Observations:** What do you notice about structural stability? How did you get each joint to work? What worked well, what didn't?	**Tips to remember:** What is something you discovered that you want to make note of for the next time?
Splice joint		
Butt joint with tie		
Butt joint with coupling		
Butt Joint with dowel		

How were you able to improve your technique through practice?

Why is it important to document your findings as you work?

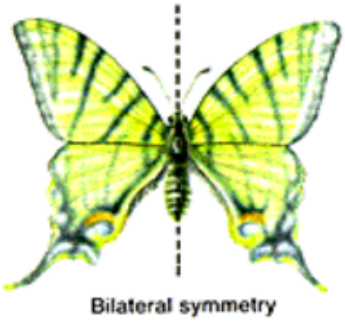


What is SYMMETRY?

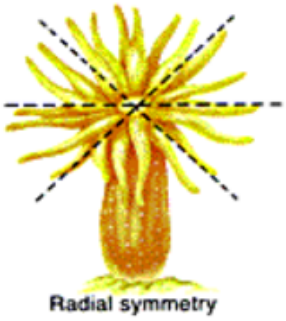


Bilateral Symmetry

Radial Symmetry



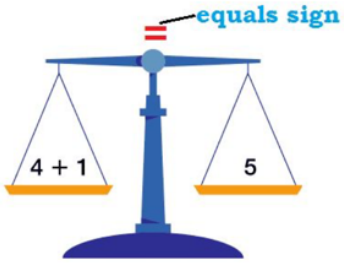
Bilateral symmetry

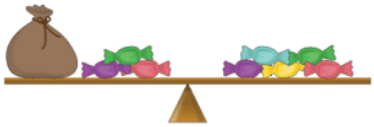


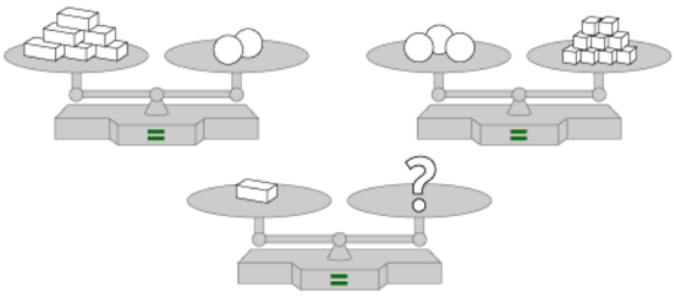
Radial symmetry

Asymmetry

What is BALANCE?







Lesson 9

Lever Experiment

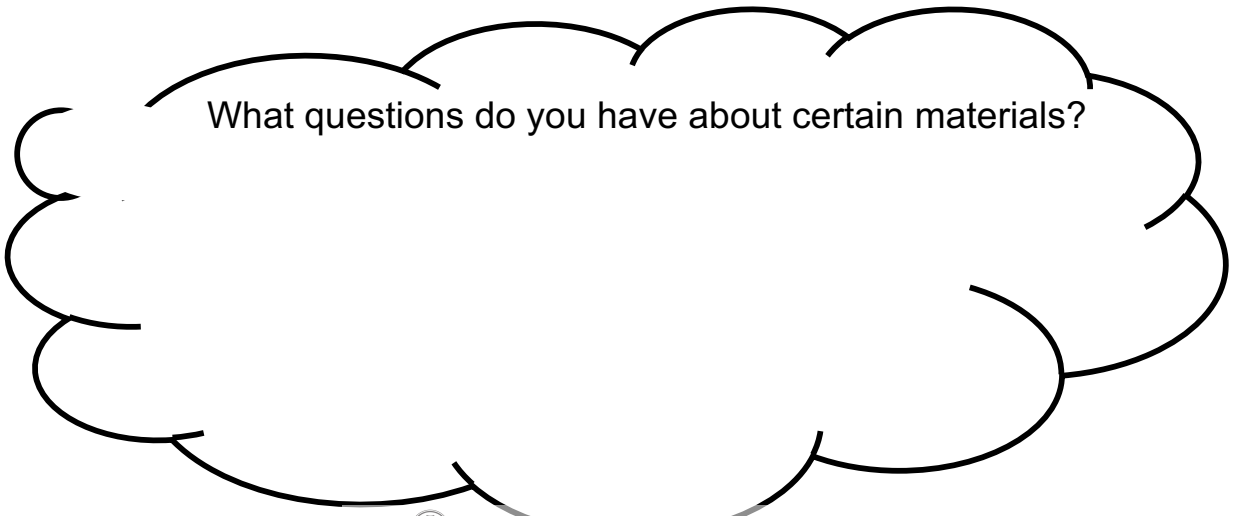
Write down three observations from your exploration (effects). What did each of these observations teach you about balance? What do you think the cause was for each?

Observation	What is the cause?	What does this teach you about balance?

Notes from Exploration

Apply Your New Knowledge

What materials are you considering for your structure at this time?	What it is about this material that is attracting you to it?
Material	
Material	
Material	
Material	



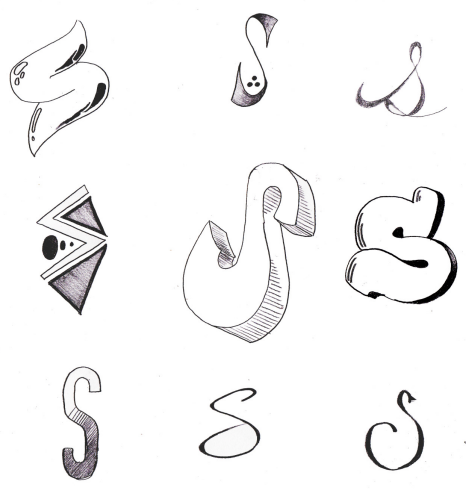
Lesson 10

The Language of Form

Form		associations
shape	Cubes, prisms, regular geometric shapes	Order, strength
Shape	Organic, irregular shapes	Nature, growth
shape	spheres	Planets, space, heavens
space	Full, crowded	busy
line	angles	Energetic, aggressive, masculine
line	curves	Fluid, organic, feminine
space	Empty, open	Free, airy, lonely, peaceful
scale	small	Dainty, delicate, cute
scale	large	Dominating, power
balance	symmetry	Order, peace
contrast	counterbalance	tension
imbalance	Asymmetry, negative space	Imbalance, instability
movement	Lines, arrows, triangles	Focus the attention, give importance
movement	Patterns, repetition	Energy, busy, excitement

Formstorm-

A brainstorm of all the ways to represent a concept in images or forms



• In thinking about the design of what you might like to build, what are some of the words or messages that appeal to you?

Now create a “formstorm” create one image and then keep playing with that form, changing it slightly each time.

Lesson 10

Choose one of these designs from your formstorm.
Make it larger and elaborate upon this idea, adding more details.

What ideas or emotions are you trying to express with this tower?

How is each person on your team represented in this design?

Collaboration

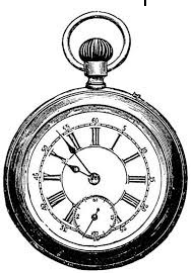
How did your ideas change and grow through your interaction with your group?

What went well?	What was challenging?

Team Roles

Taskmaster: Brings order and direction. The taskmaster checks to make sure all group members understand what needs to be done and who is doing what. Monitors the groups progress according to the timeline and the listed tasks. Calls for check-ins. keeps the group on task, and distributes work.

Time Keeper: Keeps the group aware of time constraints and deadlines and makes sure work starts on time and that no time is being wasted. Makes sure group focuses on most important issues and does not get caught up in details. Gives estimates of how much time can be allotted to each phase of the project or each task. The time keeper makes frequent time announcements and makes adjustments to the schedule as deadlines are either met or they are not. Often a group's success depends on their use of time.



Facilitator: Brings fairness and peace, or harmony. The group facilitator makes sure that everyone is heard and that all team members participate actively. They moderate team discussion by encouraging other team members to listen and may restate or paraphrase the ideas of all the teammates. Strives to create a harmonious and positive team atmosphere where everyone is included, teammates compromise and the group is able reach consensus. Often the facilitator spends more time listening and restating other's ideas rather than sharing his own ideas.

Inspector: Improves the quality of the groups work. The inspector keeps the group focused on goals and criteria. Uses the checklist or instructions and a reference to review the group's work. Notes when the criteria are met and notices when work products do not meet the criteria. Makes suggestions for improvements.

Recorder/Reporter: Takes notes during discussions and give summary of shared ideas and group decisions. Keeps the group's work, organized materials, and stores all of the important documents. Serves as group spokesperson to the class or instructor, summarizing the group's activities and or conclusions.

Role Assignments

 Taskmaster _____

 Time Keeper _____

 Facilitator _____

 Inspector _____

 Recorder/Reporter _____

What is **your role** on your team? What does that mean you will be doing throughout this project?

What do you think you will be good at in this role?

What do you think you might need help with?

Defending your ideas

How do you know that your structure will be strong and stable?

Scientists and engineers must make arguments to defend their ideas. When you hear the word "argument" you may think of a fight, but really an argument is a reason or set of reasons given to persuade others that something is right or wrong.

Your decisions should be based on EVIDENCE and REASONING

Evidence	
□ Gives specific examples from observations from experiments □ Gives examples from observations from the world	□ Uses the word "because" □ Uses logic "if . . then . . " □ Uses known rules

How do you know that your structure will be strong and stable?

Things to consider:

What materials did you use? Why?

How did you arrange the materials? Why?

How did you join the materials? Why?

How do you know that your structure will be strong and stable?

Claim:

Our structure will be strong and stable.

Evidence:

What observations of of materials or the arrangement of materials have you seen in other experiments or in the world? What do you know from past experiences?

Reasoning:

How does this knowledge (your evidence) connect to the design of your tower?

Team plan tasks and task assignments

Team Member Name					
Beginning					
Middle					
End					

Which tasks are you assigned to? What will you be responsible for?

What are some questions you have about the tasks you are responsible for?

Lesson 14

Building our Tower

As you build your tower keep track of any “incidents” or phenomena with detailed observational notes. Also be sure to jot down your thoughts about the incident and questions you have.

ENIGNEERING LOG **Date: _____**

Incident What happened? What did you see with your eyes?	Thoughts Why do you think this happened? What does this remind you of or make you think about?	Questions What are you curious or confused about?
TIME:		
TIME:		
TIME:		

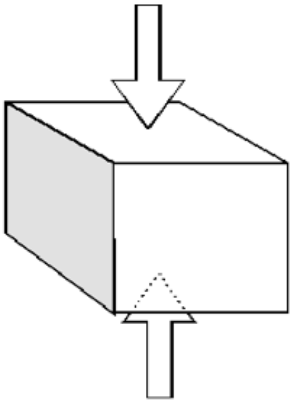
What did you learn about your materials as constructed your tower?

What did you have to change in your design?

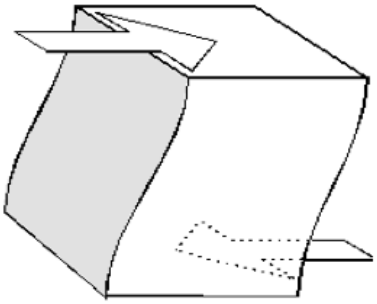
Why did you have to make those changes?

Is your structure strong and stable?

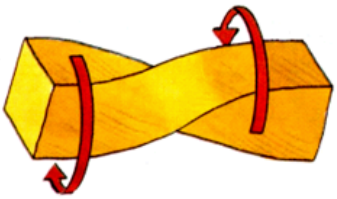
Evidence of Stress



compression

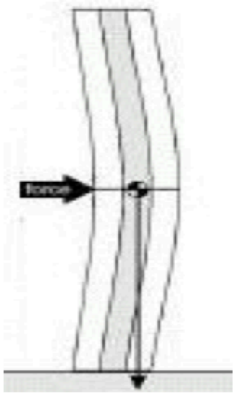


shear



torsion

wiggle



bulge

Earthquake Table Test Results

Check off everything that you see during the tests

Design 1

	Collapse	Compression	Shear	Torsion	bulge	wiggle
Low intensity						
Medium intensity						
High intensity						

Revised Design II

	Collapse	Compression	Shear	Torsion	bulge	wiggle
Low intensity						
Medium intensity						
High intensity						

Revised Design III

	Collapse	Compression	Shear	Torsion	bulge	wiggle
Low intensity						
Medium intensity						
High intensity						

What did you learn from your tests?

What questions do you have now?

What ideas do you have to solve your problem? Why did you think they might work?

Viewer Response

When people view your tower they will respond to how it looks, how it makes them feel, what it makes them think of, and what they thing it says.

What did viewers notice?	**What did viewers say the felt with they studied your work?**
What did viewers say they thought of, or were reminded of?	**What did viewers say they thought your tower was trying to say? What the meaning was behind your work?**

Reflection

How do you feel about your audience's reaction?

Did your work express what you hoped it would?

How do you feel about your tower?

Group Discussion:

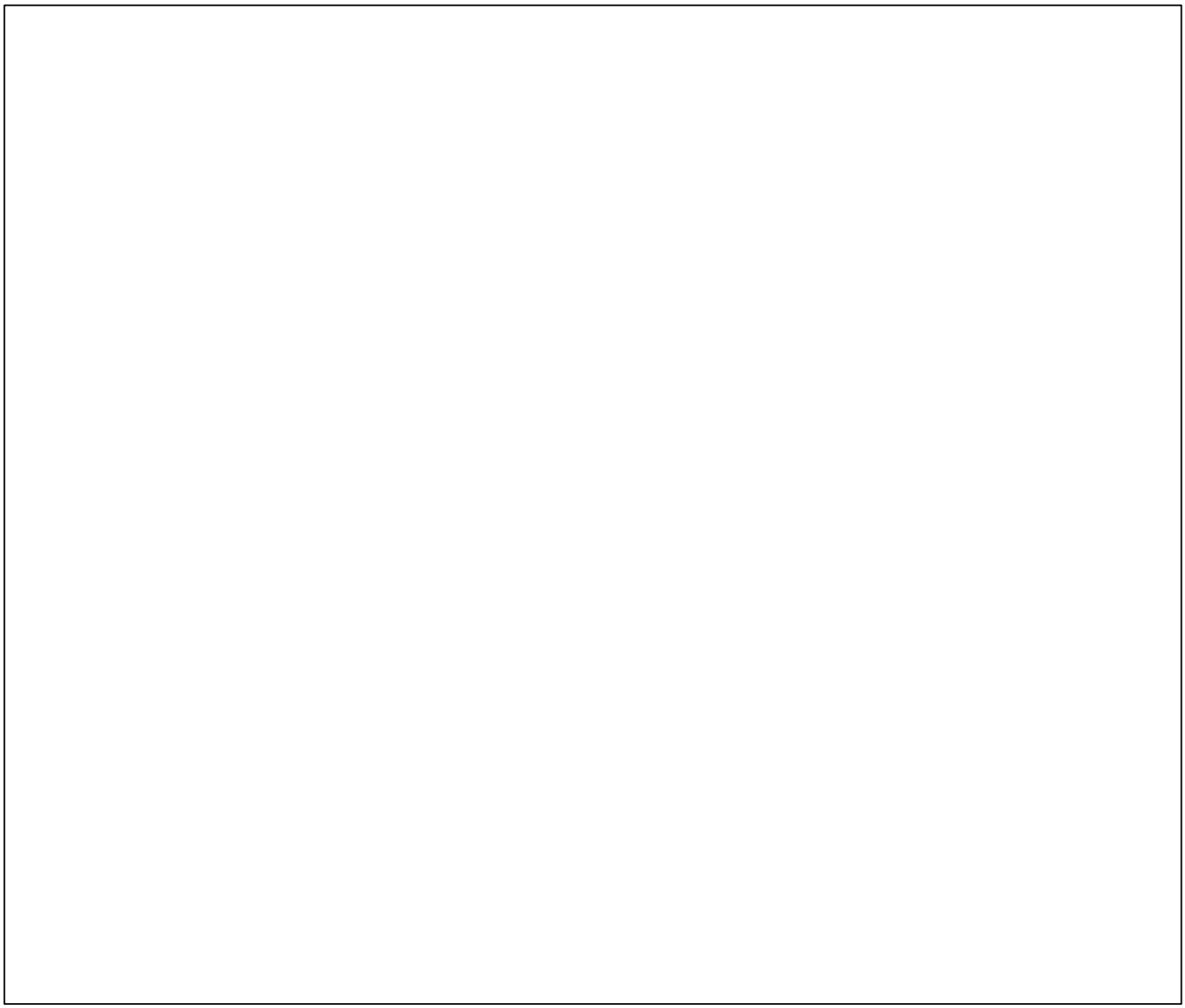
What elements would like to REMAIN?

What elements might you want to REMOVE?

What elements might you want to ADD?

Lesson 17

Draft of Revised Tower Design



What changes did your group make and why?

Group Presentation

You and your team will create a group presentation to accompany your work that will talk about HOW you worked together to create your final work, what you learned throughout this process, and how you have changed as a result.

Presentation Criteria

Content of Presentation	Delivery
☐ The presentation addresses the following questions: ☐ What did your group learn about matter and materials? ☐ What did your group learn about building? ☐ What did your group hope to express with this work? ☐ What went well? ☐ What was challenging? ☐ What did you realize during this process? ☐ What did you learn about yourself in creating this work? ☐ What questions do you have now? ☐ What has this inspired you to do?	☐ Each member presents ☐ Good voice projection ☐ Word articulation ☐ Not reading off of cards or paper (but can be used as a reminder) ☐ Eye contact ☐ Each segment is connected in some way ☐ Able to answer questions from the audience

Lesson 18

Individual Notes

How did you work together to create this work/tower?

What were some obstacles?

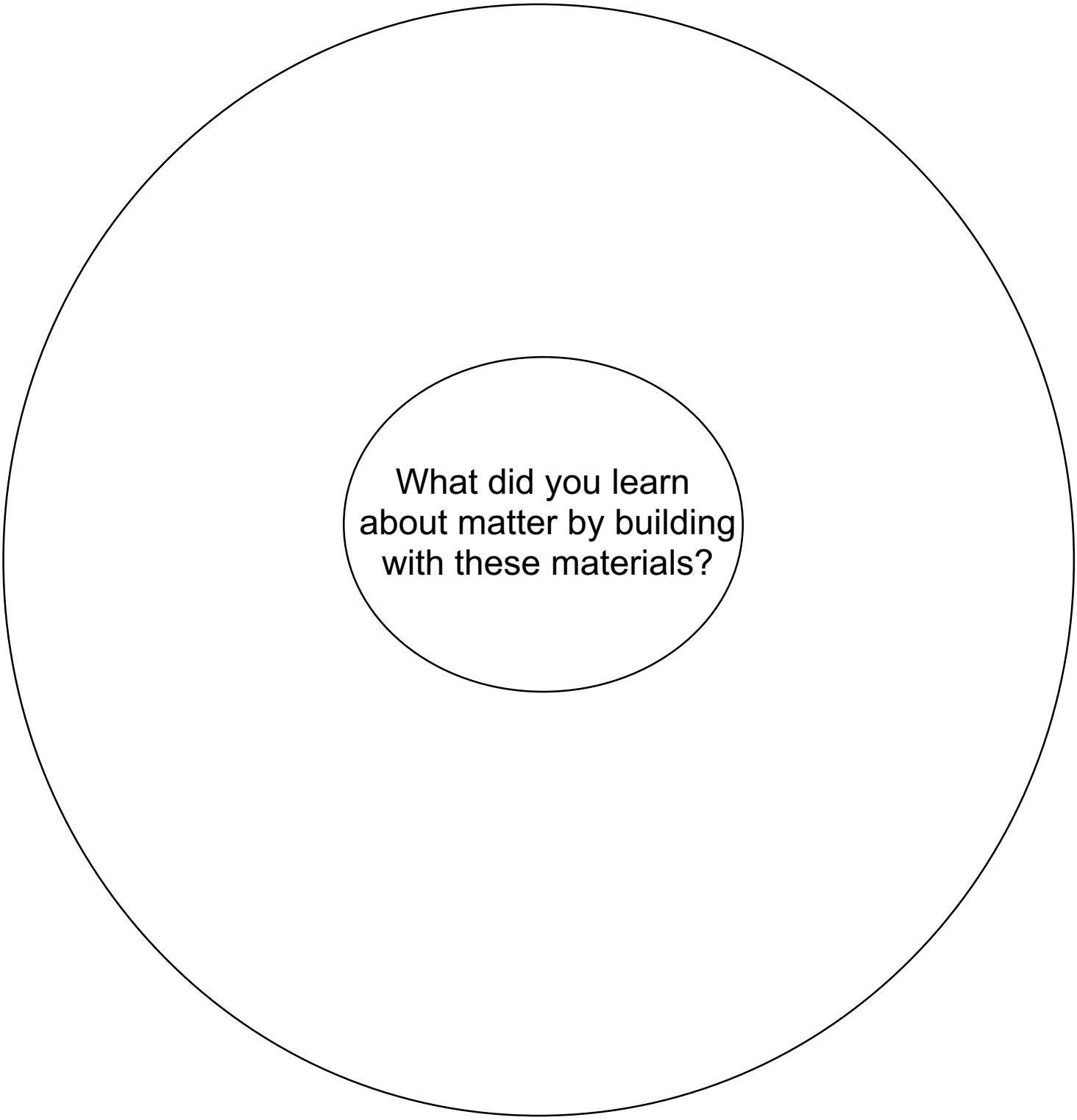
How did you overcome those obstacles?

What did you learn about building with materials? When and how did you learn this?

What did you learn about working as a team? When and how did you learn this?

What did you learn about yourself? When and how did you learn this?

Brainstorm


What did you learn about matter by building with these materials?

Lesson 19

Essential Question

How does the understanding of the materials we have to work with help us design better solutions?

Use drawings words and numbers to explain your thinking.

How has your thinking about matter and its properties changed?

I used to think _____
but now I think _____
_____
_____

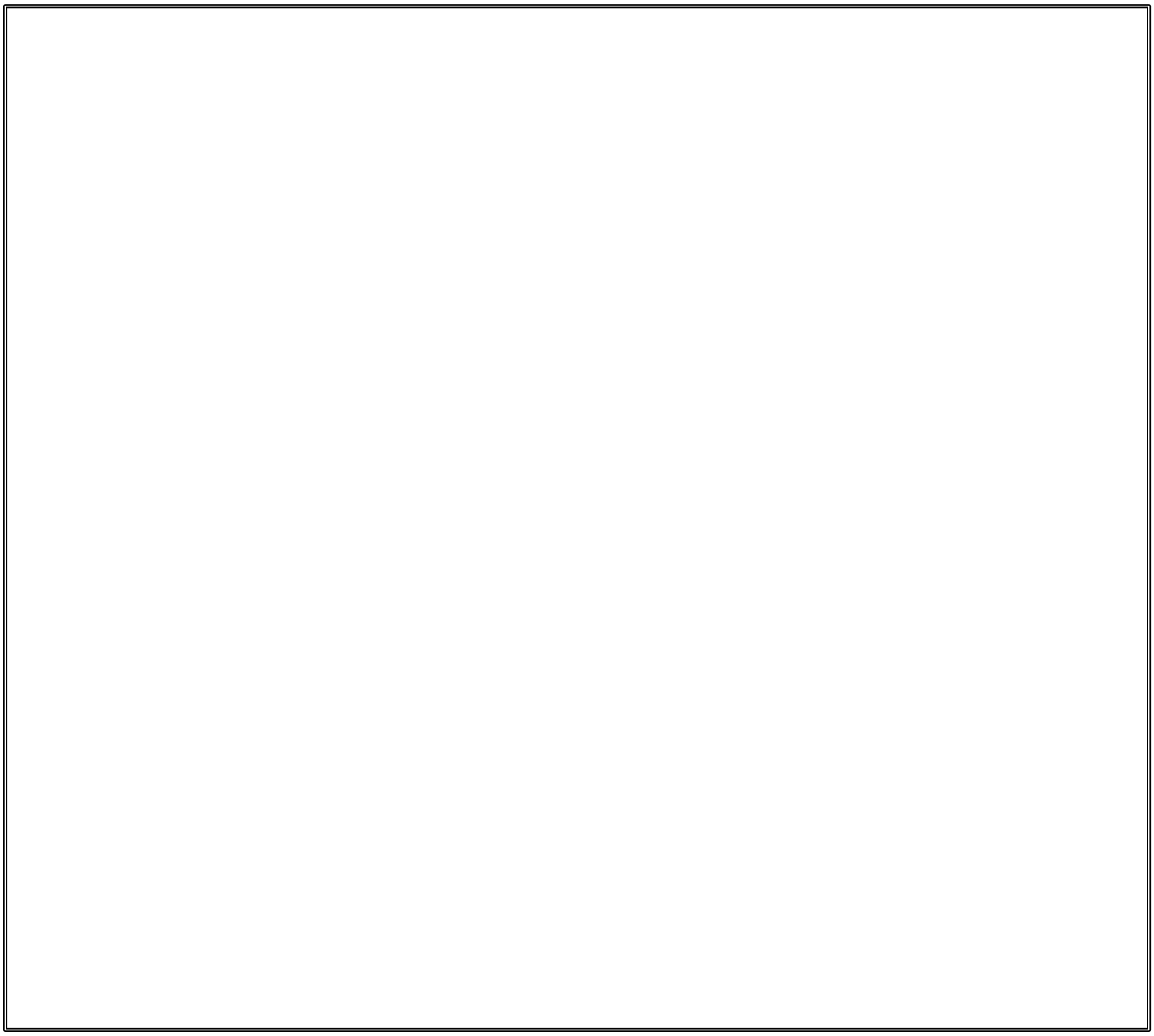
I used to think _____
but now I think _____
_____
_____

I used to think _____
but now I think _____
_____
_____

What are you still curious about? What questions about matter and building with matter do you have now?

Tower Design Revisited

Draw a design of a tower. Include the types of materials and explain how you would arrange and connect them.



Why did you choose these materials for your tower?

Why did you arrange them this way?

Why did you connect them this way?