UBC Geering Up
Engineering Outreach

Paper Sculptures

Subject: Science/ ADST	**Grade:** 6-9	**Duration:** 1-2 hours
Lesson Overview	Students will use the engineering design process and their knowledge of physics to construct an aesthetically pleasing sculpture that satisfies the building requirements.	

Curriculum Ties (in addition to satisfying multiple core competencies):

ADST (Applied Design, Skills & Technologies):

ADST Core Competencies:

- Communication
    - Collaborating: Share progress while making sure to increase feedback and collaboration.
- Thinking
    - Creative Thinking: Take creative risks in generating ideas and add to others' ideas. Thinking "outside the box" to get innovative ideas and persevere to develop them into a body of creative work over time in an area of interest or passion.
    - Critical and Reflective Thinking: Screen ideas against criteria and constraints first, students will brainstorm and think consciously about their decisions before executing their plan.
- Personal & Social
    - Social Awareness: Students will be brainstorming and problem solving with their peers in a constructive and respectful way.
    - Social Responsibility: Evaluate the influences of land, natural resources, and culture on the development and use of tools and technologies on the construction of their tower

ADST Curricular Competencies

- **Understanding Context**: Students will gather information from their peers and from their background knowledge of existing towers.
- **Defining:** Students will be able to identify the main objective for the design of their invention and any constraints by discussing with teachers and peers.
- **Ideating:** Students can work by themselves or in groups in order to generate potential ideas and add to others' ideas.
- **Prototyping:** Students will be given the opportunity to build a prototype from their potential ideas.
- **Testing:** Students will be able to test and present their prototype and gather feedback from teachers and peers.
- **Making**: After multiple rounds of testing and alterations, students will be able to construct the final product incorporating all of the planned changes.
- **Sharing**: Students can use a variety of different methods and platforms to share their constructed tower. You can also allow time for students to peruse each other's towers in groups.

Applied Skills

- During the multistep process the students will have ample opportunity to learn how to use their materials, tools, and technologies in a safe manner.
- Students will also be able to develop their design and presentation skills.

Science 6

- Newton's three laws of motion
    - First law: objects will stay stopped or in constant motion until acted upon by an outside force
    - Second law: only an unbalanced force causes acceleration
    - Third law: every force has an equal and opposite reaction force
- Effects of balanced and unbalanced forces
    - Balanced forces are equal and opposite forces (e.g., sitting in a chair)
    - Unbalanced forces are unequal; one force is larger (e.g., race cars on different ramps, mousetrap cars, rockets)
- Force of gravity

- Gravity is the force of attraction between objects that pulls all objects toward each other
- On Earth, gravity pulls objects toward the centre of the planet (e.g., falling objects, egg drop)

Content Objectives

- Apply the Engineering Design Process to solve a creative challenge with specific constraints.
- Explore Newton's Laws of Motion, gravity, and the difference between balanced and unbalanced forces through experimentation.
- Strengthen collaborative problem-solving, creative thinking, and design iteration skills.

Materials & Equipment Needed

Consumables:	Non-Consumables:

• Paper (any colours, preferably uniform in shape)
  ○ 20 sheets of paper to start
• Tape
  ○ Masking tape preferred for its ease of use
• For extension of the activity:
  ○ Objects of uniform weight	

Lesson & Activity

Lesson Stages	Learning Activities
Introduction	• Begin with a lesson on: Newton's Three Laws of Motion, balanced vs. unbalanced forces, Force of gravit. • Then introduce this engineering activity. The goal of this design challenge is to have students construct a creative structurally sound sculpture using only paper and some tape. The constraints are that it can only be made of paper and tape, it must be on a certain base size (ex: 4 popsicle sticks) and the goal is for it to be the widest sculpture without it falling over! • Encourage artistic creativity. Engineers are constantly designing new ideas and concepts to overcome problems. No two problems or issues are the same and for this reason, creativity is highly sought after in the engineering field.

Activity	**Set Up**
	• Distribute the sheets of paper to each group and one strip of tape.
	  ○ If students would like to, they must trade one sheet of paper in for another one of a different colour
	• Define constraints and building requirements:
	  ○ The sculpturre must be able to maintain its structural integrity using only the materials supplied.
	  ○ Be as wide as possible
	  ○ The sculpture must be built upon a foundation of set dimensions. This is not intended to limit students' creativity, and its primary purpose is to prevent students from laying down a single sheet of paper and saying it is

done. This required dimension can be flexible, e.g. Use 4 popsicle sticks as the base.

Brainstorming & Sketching

- Invite students to generate ideas for how to build the widest structure possible. Encourage divergent thinking, there's no single right answer.
- Prompt questions:
  - How can paper be folded or shaped to increase stability?
  - What types of bases provide support for wide structures?
  - How do towers distribute weight?
- Have students sketch their initial ideas on paper, labeling possible folds, supports, or joints.
- If working in teams, ensure all voices are heard in the planning stage.

Construction & Prototyping

- Distribute materials and begin building.
- Allow students to:
  - Exchange white paper for coloured sheets (1:1 trade)
  - Adjust their designs as they build (iterate!)
  - Fold, roll, layer, or cut paper to increase strength or aesthetics
  - Encourage them to test stability throughout by gently tapping or blowing on the sculpture to simulate real-world forces.
  - Remind students of safe use of materials and collaborative teamwork.

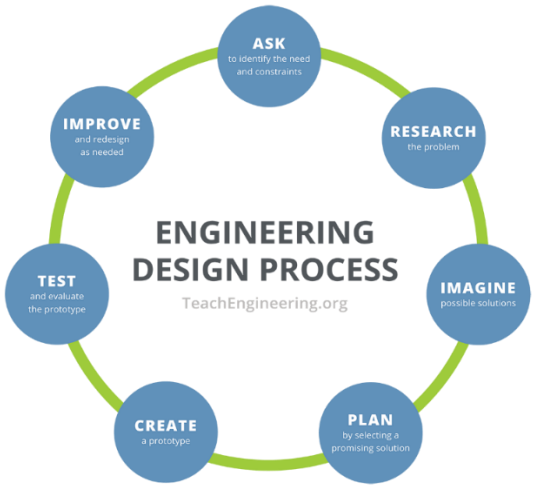
Teacher Tip: Move around the classroom offering probing questions or hints rather than solutions. Help guide students to apply

	engineering thinking and force concepts (e.g. “What would happen if this support was angled instead of vertical?”)
Closure	**Showcase the Sculptures** Let students share their work using one of the following formats: • Mini-Presentations: Each group explains their design choices, challenges, and how they overcame them. • Gallery Walk: Students walk around the room silently, leaving sticky notes with compliments or questions. • Silent Auction (just for fun!): Groups "bid" on each other's creations with tokens or tickets. **Class Discussion** Facilitate a reflective conversation with questions like: • What worked well in your design? • What challenges did you encounter? • Did your sculpture change from your original plan? Why? • What part of the engineering design cycle did you use the most? • What forces affected your sculpture? • How did creativity play a role in your engineering process? Encourage students to make connections between their experience and the science concepts (Newton’s laws, gravity, force distribution).
Step Ups & Step Downs	Set extra engineering challenges and tests for students to achieve: • Sculpture will be tested on how much weight it can hold before collapsing. • A fan blowing wind against the sculpture from a set distance • And many more! You are welcome to introduce new challenges and tests in your own classroom, but these should be a good starting point.

	Let students budget all of their building supplies: • Instead of the preset 20 sheets of paper and 2 strips of tape or 10 extra sheets of paper, students will have to "buy" their supplies from the teacher using an amount of simulated money • E.g., each group will be given $40. A sheet of paper costs $2, and a long strip of tape will cost $5.

Background Knowledge

The Engineering Design Cycle:



1. Ask
    - What is the problem we're trying to solve?
    - What are the limits that our solution needs to follow?
2. Research
    - Has someone already created something like this?
    - Who are the experts in this field?
3. Imagine
    - Brainstorm a large quantity and variety of ideas before narrowing the options.
4. Plan
    - What criteria should we use to narrow down our ideas?
    - Which ideas need to be screened based on the original constraints we identified?

5. Create
    - What kind of prototypes can we create? A sketch, scale model, CAD model, computer simulation, etc
6. Test
    - What does our final design need to accomplish? Can we test this with the prototype we made?
    - Run an experiment
    - Create a computer simulation
    - What information are we looking to gain from these tests?
7. Improve
    - Based on the results from the testing, what can we improve on our design?
    - Are there certain aspects we found too difficult to create?

Newton's Laws of Motion

1. Every body continues in a state of rest or uniform motion (constant velocity) in a straight line unless acted on by a force.
2. Acceleration (change in speed or direction) of object is proportional to: applied force F divided by the mass of the object m. only an unbalanced force causes acceleration
3. To every action, there is an equal and opposite reaction, i.e. forces are mutual. A more useful equivalent statement is that interacting objects exchange momentum through equal and opposite forces.

Balanced Forces and Unbalanced Forces

- Balanced Force: Forces that are equal in size, but opposite in direction. Balanced forces cause no movement because they balance each other out
- Unbalanced Force: Forces that are unequal in size, will cause movement in the direction of the stronger force.

Forces of Gravity:

- Gravity is the force of attraction between objects that pulls all objects toward each other
- On Earth, gravity pulls objects toward the centre of the planet (e.g., falling objects, egg drop)

Additional Resources

- Newton's laws of motion
  - https://youtu.be/JGO_zDWmkvk
  - https://youtu.be/qgIm96-WkwY
- Forces
  - https://youtu.be/FnieXqwKbbU
  - https://youtu.be/EwY6p-r_hyU
- Paper Towers:
  - https://youtu.be/9Bhl8HkmCzo
  - https://youtu.be/dJr2DJRKy5c