



ONTARIO COUNCIL
FOR TECHNOLOGY
EDUCATION

Grade 5

**Forces Acting on Structures
and Mechanisms**

ONLINE RESOURCE

June 2020

Structures and Mechanisms - Forces Acting on Structures and Mechanisms

Grade 5

Activity 1

Development of Curiosity and Wonder - How do structures stay strong and stable? What forces are acting on them?

Scientific and Technological Concepts: Structures are all around us. Students will be familiar with the concept of what a structure is from Grade 3. Here we will explore the forces that act on structures, which must be considered when planning and building structures.

There are five internal forces that will be explored:

Compression: a pushing force that squeezes or compacts a material together.

Tension: a pulling force that stretches or pulls a material apart.

Bending: When two complementary forces are acting on a material or object at the same time (tension and compression)

Torsion: A force that acts on a material by twisting it in opposite directions.

Sheer: A force that tears or bends a material by pushing in parts of the material in opposite directions.

[Internal and External Forces Explained](#) - A comprehensive virtual lesson on the forces with practical examples to help students understand.

External Forces such as live loads (the weight inside the structure that is temporary and often changes such as people or materials within the structure) and dead loads (the structures completed weight which is constant and does not change over time) must also be considered especially when exploring environmental forces such as earthquakes, hurricanes, tsunamis and tornadoes.

[Science Trek: Force and Motion](#) - This is a great video from PBS that reviews forces and motion if students require a refresher.

Learning Goal:

Students will

- Discover the internal and external forces acting on a structure
- Conduct investigations that illustrate these forces
- Draw conclusions about how the forces would act on structures and how they could counteract these forces when building

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Expectations (Overall & specific):

Overall: identify forces that act on and within structures and mechanisms, and describe the effects of these forces on structures and mechanisms.

Specific:

2.5 use appropriate science and technology vocabulary, including tension, compression, torque, system, and load, in oral and written communication

3.1 identify internal forces acting on a structure (e.g., compression [squeezing], tension [stretching]), and describe their effects on the structure

3.2 identify external forces acting on a structure (e.g., the weight of people and furniture in a house, wind blowing on a tent, the movement caused by a passing train), and describe their effects on the structure, using diagrams

Equipment & Materials	Personal Protective Equipment (PPE)
<ul style="list-style-type: none"> Virtual Forces Classroom Slide Scissors Marshmallows (5 large) 	<ul style="list-style-type: none"> Protective eyewear

Safety Considerations:

- Scissors should be handled carefully
- Protective eyewear should be worn during the experiment
- Students should not eat the marshmallows

What does the teacher do?	What do the students do based on the Technological Problem-Solving Skills Continuum?
<p>1. The teacher will post the link to the Forces Virtual Classroom. Students should view and explore the slide in present mode. You may keep it as an exploratory activity or provide them specific directions for viewing and with the activity sheet (refer to Appendix A) to complete after viewing.</p>	<p>Initiating and Planning</p> <ul style="list-style-type: none"> Engage in prerequisite learning through information posted in the virtual classroom slide (Minds On) Gather materials Predict and record the effect of the internal forces on the recording sheet

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2. To explore the forces they learned about in the Virtual classroom, students will complete the *Marshmallow Forces* activity. Teachers post the activity (refer to Appendix B). Teachers may wish to post an instruction video of themselves to accompany the exploration sheet.

Sample accommodations:

- The teacher may wish to video themselves doing the experiments for students who do not have access to the materials.
- Teachers may wish to use sponges or halal marshmallows in place of the marshmallows as a religious accommodation.

Sample Troubleshooting:

- The virtual classroom link above will force a copy of the classroom to your drive. Reminder that students should view the link in present, this takes them directly to the site linked in the slide.

Performing and Recording

- Students complete the *Marshmallow Forces* experiment and record their results on the recording sheet

Analysing and Interpreting

- Students take their new learning and apply it to answer the Activity sheet questions that go with the Forces virtual classroom
- After completing the *Marshmallow Forces* activity, students draw conclusions based on their findings about the internal forces acting on a structure
- Generate possible solutions when building to counteract the internal forces acting on a structure

Communicating

- Student answers should include references to relevant concepts and use unit vocabulary introduced in these activities

Opportunities for assessment (Links to assessment pieces, organizers):

- Assessment for learning: Student answers will determine understanding of the concepts of internal and external forces acting on structures. Teachers may wish to review definitions depending on student responses and understanding
- Assessment as Learning: Exit Card (refer to Appendix C)

Cross Curricular Opportunities:

Language: Students could complete research on natural disasters or a famous structure of interest to them and produce a video, website or media text of their choice to share their findings.

Reading

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1.1 read a variety of texts from diverse cultures, including literary texts (e.g., short stories, poetry, myths, culturally focused legends, plays, biographies, novels), graphic texts (e.g., graphic novels, hobby or sports magazines, advertisements, logos, atlases, graphic organizers, charts and tables), and informational texts (e.g., editorials, reports, biographies, textbooks and other non-fiction materials, print and online articles, personal electronic and online texts such as e-mails)

1.4 demonstrate understanding of a variety of texts by summarizing important ideas and citing supporting details

1.6 extend understanding of texts by connecting the ideas in them to their own knowledge, experience, and insights, to other familiar texts, and to the world around them

Writing

1.2 generate ideas about a potential topic and identify those most appropriate for the purpose

1.3 gather information to support ideas for writing, using a variety of strategies and a range of print and electronic resources

1.5 identify and order main ideas and supporting details and group them into units that could be used to develop several linked paragraphs, using a variety of strategies

2.8 produce revised, draft pieces of writing to meet identified criteria based on the expectations related to content, organization, style, and use of conventions

Media Literacy

3.1 describe in detail the topic, purpose, and audience for media texts they plan to create

3.2 identify an appropriate form to suit the specific purpose and audience for a media text they plan to create, and explain why it is an appropriate choice

3.4 produce a variety of media texts for specific purposes and audiences, using appropriate forms, conventions, and techniques

References:

Papa, L., Romano, L., & Saulle, E. (2013). *Grade 4/5 Science Unit for Pulleys and Gears and Forces Acting on Structures*. Teaching Rocks.

<https://teachingrocks.ca/wp-content/uploads/2013/01/Demo-Gr-45-Science-Unit-Pulleys-and-Gears.pdf>

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Appendix A

Forces Virtual Classroom Activity Sheet

1. Match the internal force and the definition

_____1. Compression

_____2. Tension

_____3. Bending

_____4. Torsion

_____5. Sheer

A- a force that acts on a material by twisting it in opposite directions.

B- a force that tears or bends a material by pushing in parts of the material in opposite directions.

C- a pulling force that stretches or pulls a material apart.

D- when two complementary forces are acting on a material or object at the same time (tension and compression)

E- a pushing force that squeezes or compacts a material together.

2. Look at the diagram of the house. Using arrows and labels, identify where the external forces would be acting on this house.



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Appendix B

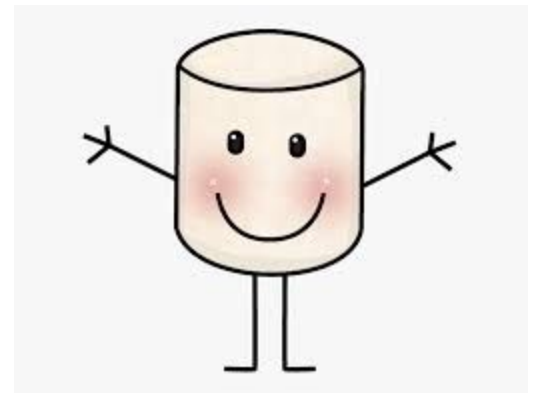
Marshmallow Forces

Did you know that a marshmallow is a structure?
We can use this delicious structure to see how internal forces act on a structure.

Purpose: To explore how internal forces act on structures.

Hypothesis: You will be making a prediction about how each force will act on the marshmallow before each of the steps.

Materials: 5 large marshmallows
A pair of scissors
Recording sheet (see below)



Procedure:

1. What do you think will happen to the marshmallow if you press down on it with your hand? Which force do you think is at work here? Write your prediction on the recording sheet. After you have written your prediction, set 1 marshmallow on the table and press down on it with your hand. Record your observations.
2. What do you think will happen to the marshmallow if you hold each end and gently pull? Which force do you think is at work here? Write your prediction on the recording sheet. After you have written your prediction, take a second marshmallow and take each end and gently pull. Record your observations.
3. What do you think will happen to the marshmallow if you hold one end and twist the other? Which force do you think is at work here? Write your prediction on the recording sheet. After you have written your prediction, take a third

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marshmallow and hold one end while you turn the other end one full turn. Record your observations.

4. What do you think will happen to the marshmallow if you hold each end and bend it in the middle? Which force do you think is at work here? Write your prediction on the recording sheet. After you have written your prediction, take a fourth marshmallow and with your thumbs in the center gently pull down on either end. Record your observations.
5. What do you think will happen to the marshmallow if you use scissors and cut it? Which force do you think is at work here? Write your prediction on the recording sheet. After you have written your prediction, take a fifth marshmallow and carefully cut it in half. Record your observations.

Observations: Complete the recording sheet with what you observed.

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Marshmallow Forces Recording Sheet

	Prediction: What force is at work?	Prediction: What will happen to the marshmallow after the force is applied?	Draw the marshmallow before the force is applied	Draw the marshmallow after the force is applied	What force acted on the marshmallow?
Marshmallow 1					
Marshmallow 2					
Marshmallow 3					
Marshmallow 4					
Marshmallow 5					

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Conclusions:

1. For each force, describe the effect of that force on the structure of the marshmallow.

Tension:

Compression:

Bending:

Shear:

Torsion:

2. Why is it important for architects and engineers to consider these forces when designing and building structures?

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3. If you were the structural engineer, what suggestions would you have for reinforcing the structure of the marshmallow to help make it stronger and counteract the internal forces acting on it?

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Appendix C

Forces Acting On Structures

Rate your level of knowledge and understanding of each of the statements below.

1. I feel comfortable with the definitions of internal forces and can explain each one in my own words.

2. I can identify the external forces that act on structures and can show how they act on structures using a diagram.

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Activity 2 - Exploring the Forces of Natural Phenomena

Structured to develop technological problem solving skills

Scientific and Technological Concepts: Natural disasters can be the cause of the destruction of man-made structures. Tornadoes, tsunamis, hurricanes and earthquakes create external forces which produce stresses on the materials that are used to build the structures we use everyday. All structures around us are built to withstand live loads but sometimes, if the force is too strong or they are not engineered well, these powerful external forces of Mother Nature can create a disaster. The external forces such as wind, water and the vibration of the earth when an earthquake happens create internal forces within a structure. Internal forces such as tension, compression, bending, shear and torsion can destroy the inner framework of a structure even though it is made of strong materials.

Engineers need to be aware of causes and behaviour of natural phenomena in the planning and building of structures in cities that are prone to these forces of nature. Understanding how materials will react and how to incorporate architectural design elements that allow the structure to remain strong and stable while providing its function is a challenge. Students will be exploring these challenges on a much smaller scale.

[Engineering to Prevent Natural Disasters](#) - This page by Teach Engineering has some fantastic reference materials that could be used to help explain to students how this is accomplished.

[How to Demonstrate Engineering Principles](#) - A good visual of how to build structures that resist a simulated earthquake.

[History and Testing Shapes of Strength for Building](#) - A short video that shows how different shapes and materials can be combined for strength when building

[Natural Disasters](#) - A video that explains some natural disasters and how engineers have come up with ways to withstand them.

[The Engineering Design Process: A Taco Party](#) - This is a quick video teaching students about the different steps in the Engineering Design process which they will be using in this lesson.

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Learning Goal:

Students will

- Conduct research and analysis of a natural phenomena and apply that knowledge to the construction of a structure of their choice (building, bridge, tower).
- Use the engineering design process to design, build, test and improve on their structure.
- Identify the effects of forces from natural phenomena on the built environment

Expectations (Overall & specific):

Overall:

-investigate forces that act on structures and mechanisms

Specific:

1.1 analyse the effects of forces from natural phenomena (e.g., tornadoes, hurricanes, earthquakes, tsunamis) on the natural and built environment

2.1 follow established safety procedures for working with tools and materials

2.3 use scientific inquiry/research skills to investigate how structures are built to withstand forces

2.4 use technological problem-solving skills to design, build, and test a frame structure (e.g., a bridge, a tower) that will withstand the application of an external force (e.g., a strong wind or simulated vibrations from a train) or a mechanical system that performs a specific function (e.g., a building crane)

2.5 use appropriate science and technology vocabulary, including tension, compression, torque, system, and load, in oral and written communication

3.4 describe forces resulting from natural phenomena that can have severe consequences for structures in the environment (e.g., a house loses its roof in a windstorm), and identify structural features that help overcome some of these forces (e.g., cross supports for roofs, steel beams in bridges)

Equipment & Materials	Personal Protective Equipment (PPE)
<ul style="list-style-type: none"> • Found building materials such as popsicle sticks, cardboard, newspaper, coffee stir sticks, drinking straws, tooth picks, Qtips • Fastening materials such as tape, plasticine glue, or hot glue • Scissors • ruler 	<ul style="list-style-type: none"> • Protective eyewear

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- Testing devices (hair dryer, fan, shake table)
Instructions for the shake table can be found at [Shake Table Instructions](#)) it requires additional materials to those listed here

Safety Considerations:

- Students should be careful when using hot glue guns. Hot glue guns should be used on a stable work surface. Students should be aware of the cord. Adult supervision is recommended.
- Students should be careful when using sharp items such as scissors.

What does the teacher do?	What do the students do based on the Technological Problem-Solving Skills Continuum?
<ol style="list-style-type: none"> 1. Present the design challenge (refer to Appendix D) to students, identifying the parameters of the challenge prior to student selection of natural phenomena. 1. Share the success criteria (refer to Appendix F) and rubric (refer to Appendix G) with students. 2. Present the <i>Natural Disaster Research Recording sheet</i> (refer to Appendix E) for students to begin investigating the natural phenomena they have chosen. 3. Conference with students at different checkpoints throughout the process. 4. Guide students as required. <p>Sample accommodations:</p> <ul style="list-style-type: none"> • The teacher may wish to limit the challenge to a specific natural phenomena or type of 	<p>Initiating and Planning</p> <ul style="list-style-type: none"> • Choose a natural phenomena (earthquake, tsunami, hurricane, or tornado) and research how it affects the natural and built environment. Record their findings on the <i>Natural Disaster Research Recording Sheet</i> (refer to Appendix E) • Complete the planning step in the design challenge packet (refer to Appendix D) and conference with the teacher • Gather the materials they will require for building <p>Performing and Recording</p> <ul style="list-style-type: none"> • Using their plan, students build their structure • Record any design or building challenges, and any adjustments they made to their design (refer to Appendix D) • Test their structure and record the results (refer to Appendix D).

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<p>structure</p> <ul style="list-style-type: none"> The teacher may wish to provide students with specific sites or videos for research purposes 	<p>Analysing and Interpreting</p> <ul style="list-style-type: none"> Identify where their structure was successful or unsuccessful. Suggest ways in which the design could be improved to make it successful <p>Communicating</p> <ul style="list-style-type: none"> Using diagrams and words to communicate the results of their test and share how engineers use what they know about internal and external forces to plan for natural occurrences on structures.
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Opportunities for assessment (Links to assessment pieces, organizers):

- On-going assessment of learning through conferences with students as they work through the Design Process
- Rubric for completed Structure (refer to Appendix G) and accompanying Reflection (found in the Communicate section of the design challenge packet Appendix D)

Cross Curricular Opportunities:

Reading

1.1 read a variety of texts from diverse cultures, including literary texts (e.g., short stories, poetry, myths, culturally focused legends, plays, biographies, novels), graphic texts (e.g., graphic novels, hobby or sports magazines, advertisements, logos, atlases, graphic organizers, charts and tables), and informational texts (e.g., editorials, reports, biographies, textbooks and other non-fiction materials, print and online articles, personal electronic and online texts such as e-mails)

1.4 demonstrate understanding of a variety of texts by summarizing important ideas and citing supporting details

1.6 extend understanding of texts by connecting the ideas in them to their own knowledge, experience, and insights, to other familiar texts, and to the world around them

Writing

1.2 generate ideas about a potential topic and identify those most appropriate for the purpose

1.3 gather information to support ideas for writing, using a variety of strategies and a range of print and electronic resources

Social Studies

Students can investigate how climate change has led to an increase in natural disasters and how these affect the people, built and natural environment in these areas.

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B2.1 formulate questions to guide investigations into social and/or environmental issues in Canada from various perspectives, including the perspective of the level (or levels) of government responsible for addressing the issues

B2.2 gather and organize a variety of information and data that present various perspectives about Canadian social and/or environmental issues, including the perspective of the level (or levels) of government responsible for addressing the issues

B2.3 analyse and construct maps in various formats, including digital formats, as part of their investigations into social and/or environmental issues

B3.5 describe key actions taken by different levels of government to solve some significant national, provincial/territorial, and/or local issues

References:

WGBH Educational Foundation. (2018). *Build | Seismic Shake-Up . DESIGN SQUAD GLOBAL | PBS KIDS*. Design Squad Seismic Shake Up.
<https://pbskids.org/designsquad/build/seismic-shake-up/>

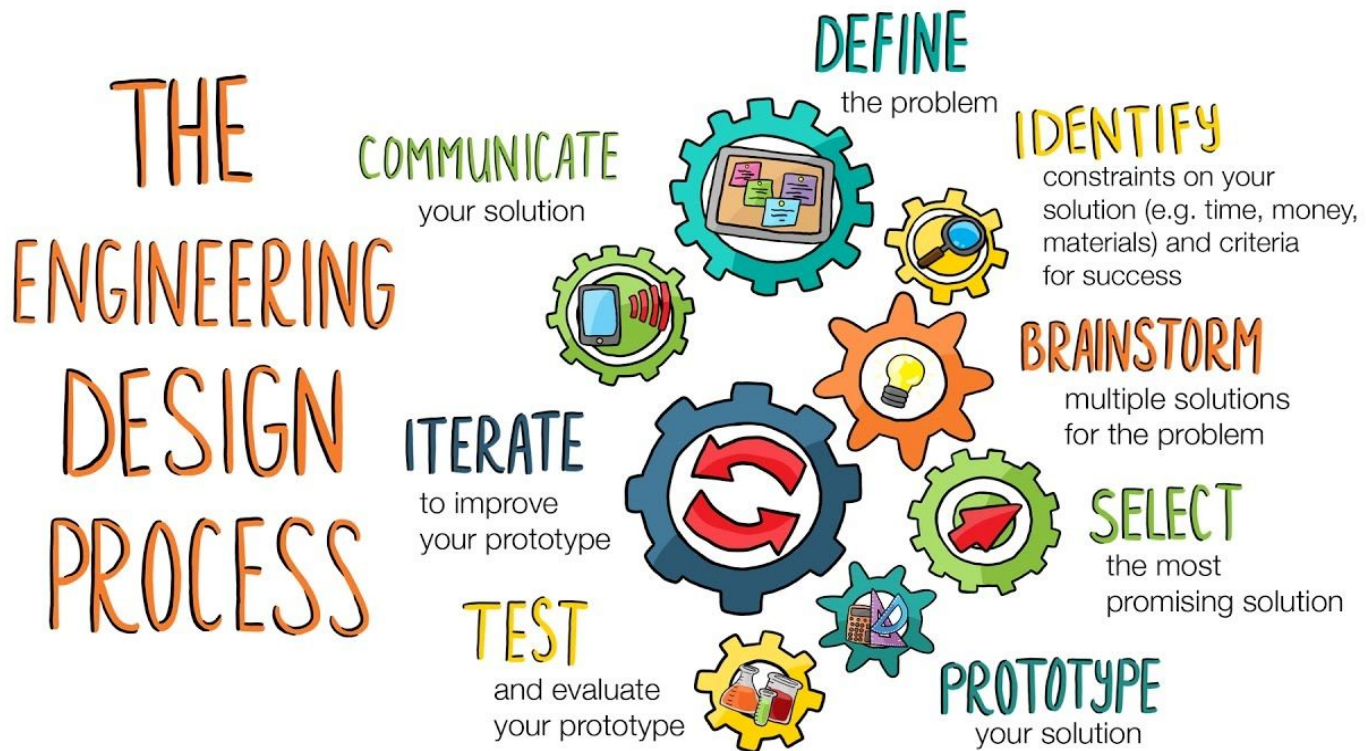
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Appendix D

Design Challenge Packet

Using the Design Engineering Process pictured below you will explore a natural force of nature (Earthquake, Tsunami, Hurricane or Tornado) and design, build and test a structure to withstand a simulated version of that natural disaster.



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Define the problem:

What is the problem you are trying to solve? Consider the following questions: What strategies will you use to ensure that you build a structure capable of withstanding an external force? What function is your device intended to perform?

What did you learn from your background research that you can apply to the problem? Are there any further questions you have?

Are there any design requirements that your solutions to the problem must meet? What are they?

What materials are available for you to use?

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Brainstorm:

Brainstorm several ideas to solve the problem below. Include diagrams and labels where you think that would help someone understand your idea. Consider the following questions as you brainstorm: How will you test your structure or device? What safety measures do you need to consider when building and testing it? How will you know if your structure or device was successful?

Idea 1

Idea 2

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Idea 3

Idea 4

Idea 5

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Select:

Evaluate each of your ideas by asking yourself “What are the best parts of the design? What are the possible weaknesses of the design?” After evaluating each idea, select the one you think will best solve the problem and meet the challenge. Record your choice below and explain why you have selected that idea.

In the space below draw and label a diagram of your design and list the materials you will need to build it.



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Prototype:

Build your structure. Record below any challenges or changes you made to your original design as you built it.

Test:

Test your structure. After you have tested, answer the following questions.

Did your structure withstand the forces you placed on it like you thought it would? Why or why not?

What parts of your structure performed as you had hoped? Why do you think they worked well?

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What parts of your structure failed? How would you want to change or improve it if you could develop a new idea?

Make any improvements to your structure that you think will help it perform better during testing. Record those changes below.

Test your structure again. What were the results of the second test? Did your changes improve the strength of your structure?

Communicate:

My design was effective in meeting the challenge because...

One challenge that I faced in the construction of my final design was...

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I solved this problem by taking the following steps...

The overall effectiveness of my solution to this problem in the final testing of my product was...

Looking back, another way to resolve this problem would have been...

Something I learned from participating in this design challenge is...

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Appendix E

Natural Disaster Research

1. Which natural phenomena are you interested in learning more about?
2. Use the internet and available materials to investigate your natural phenomena. Record your findings below using jot note format. Consider the following questions as you research: What different materials and construction techniques are used to build structures that may be subjected to forces from natural phenomena such as earthquakes? In what ways are structures modified to allow them to stand up to forces from natural phenomena such as tornadoes and hurricanes? What standard building techniques are used to ensure that structures can withstand forces placed upon them?
3. List the website URLs that you used in your research.

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4. Record any ideas, drawings or ah-ha moments you may have had for the structure you plan to build. This could be design ideas, ideas for materials or ways you could simulate the forces of your chosen natural phenomena for the purposes of testing your structure.

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Appendix F

Forces Acting On Structures Design Challenge - Natural Forces Success Criteria

- I have completed the Natural Disaster Research for my chosen natural phenomena and can explain how the forces of the chosen natural phenomena may affect structures.
- I have chosen a structure to design, build and test against a simulated natural disaster.
- I have had at least 2 conferences with my teacher to discuss my progress.
- I have completed the Design Challenge packet instructions and questions completely and thoroughly.

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Appendix G

Forces Acting on Structures - Design Challenge Natural Forces

- analyse the effects of forces from natural phenomena (e.g., tornadoes, hurricanes, earthquakes, tsunamis) on the natural and built environment
- use scientific inquiry/research skills (see page 15) to investigate how structures are built to withstand forces
- use technological problem-solving skills (see page 16) to design, build, and test a frame structure (e.g., a bridge, a tower) that will withstand the application of an external force

Expectation	Level 1	Level 2	Level 3	Level 4
Thinking and Investigation: 2.3 use scientific inquiry/research skills to investigate how structures are built to withstand forces	-uses processing skills and/or strategies with limited effectiveness	-uses processing skills and/or strategies with some effectiveness	-uses processing skills and/or strategies with considerable effectiveness	-uses processing skills and/or strategies with a high degree of effectiveness
Application 2.4 use technological problem-solving skills to design, build, and test a frame structure (e.g., a bridge, a tower) that will withstand the application of an external force (e.g., a strong wind or simulated vibrations from a train) or a mechanical system that performs a specific function (e.g., a building crane)	-applies knowledge and/or skills in familiar contexts with limited effectiveness	-applies knowledge and/or skills in familiar contexts with some effectiveness	-applies knowledge and/or skills in familiar contexts with considerable effectiveness	-applies knowledge and/or skills in familiar contexts with a high degree of effectiveness
Knowledge and Understanding 3.4 describe forces resulting from natural phenomena that can have severe consequences for structures in the environment (e.g., a house loses its roof in a windstorm), and identify structural features that help overcome some of these forces (e.g., cross supports for roofs, steel beams in bridges)	-demonstrates limited knowledge and/or understanding of content	-demonstrates some knowledge and/or understanding of content	-demonstrates considerable knowledge and/or understanding of content	-demonstrates a thorough knowledge and/or understanding of content

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Thinking and Investigation -plan effectively prior to building	-uses planning skills and/or strategies with limited effectiveness	-uses planning skills and/or strategies with some effectiveness	-uses planning skills and/or strategies with considerable effectiveness	-uses planning skills and/or strategies with a high degree of effectiveness
Thinking and Investigation -uses creative thinking and effective strategies to solve building problems	-uses critical/creative thinking processes, skills, and/or strategies with limited effectiveness	-uses critical/creative thinking processes, skills, and/or strategies with some effectiveness	-uses critical/creative thinking processes, skills, and/or strategies with considerable effectiveness	-uses critical/creative thinking processes, skills, and/or strategies with a high degree of effectiveness
Communication 2.5 use appropriate science and technology vocabulary, including tension, compression, torque, system, and load, in oral and written communication	uses conventions, vocabulary, and terminology of the discipline with limited effectiveness	uses conventions, vocabulary, and terminology of the discipline with some effectiveness	uses conventions, vocabulary, and terminology of the discipline with considerable effectiveness	uses conventions, vocabulary, and terminology of the discipline with a high degree of effectiveness

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Activity 3 - Amusement Park Ride Design Challenge

Guided development of technological problem solving skills

Scientific and Technological Concepts: This lesson builds on the prior knowledge of simple machines and how those machines can be used alone or in combination to lessen the amount of work required to complete a task. A simple machine can increase or change the direction of the force that is applied. Forces can be increased (friction) or decreased (gravity) over distance. Force is transmitted through the components of the mechanical system (pulleys, gears, wheels and axles). Mechanical systems are all around us and an amusement park is a real world familiar example for students to identify with.

Learning Goal:

Students will

- Design, build and test one of two amusement park ride choices using found materials
- Create a presentation to share their completed ride design
- explain the advantages and disadvantages of different types of mechanical systems

Expectations (Overall & specific):

Overall:

- analyse social and environmental impacts of forces acting on structures and mechanisms
- identify forces that act on and within structures and mechanisms, and describe the effects of these forces on structures and mechanisms

Specific:

2.1 follow established safety procedures for working with tools and materials

2.4 use technological problem-solving skills to design, build, and test a frame structure that will withstand the application of an external force or a mechanical system that performs a specific function

2.6 use a variety of forms to communicate with different audiences and for a variety of purposes (e.g., make an oral presentation explaining the techniques they used to build a model of a bridge that can withstand vibrations from a train)

3.3 explain the advantages and disadvantages of different types of mechanical systems

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Equipment & Materials	Personal Protective Equipment (PPE)
<ul style="list-style-type: none"> • Found building materials such as popsicle sticks, cardboard, newspaper, coffee stir sticks, drinking straws, tooth picks, Qtips, pool noodles or pipe insulation, marbles • Fastening materials such as tape, plasticine glue, or hot glue • A piece of bristol board • Scissors • ruler 	<ul style="list-style-type: none"> • Protective eyewear

Safety Considerations:

- Students should be careful when using hot glue guns. Hot glue guns should be used on a stable work surface. Students should be aware of the cord. Adult supervision is recommended.
- Students should be careful when using sharp items such as scissors.

What does the teacher do?	What do the students do based on the Technological Problem-Solving Skills Continuum?
<ol style="list-style-type: none"> 1. Review: Students require prerequisite knowledge of mechanical systems and how forces are increased or reduced using mechanical systems. Simple Machines for Kids: Science and Engineering for Children 2. Provide the students with the design challenge (refer to Appendix H), success criteria refer to Appendix I) and rubric (refer to Appendix J). 3. Conference with students at various points 	<p>Initiating and Planning</p> <ul style="list-style-type: none"> • Students choose which of the 2 options they would like to build • Using the design packet (refer to Appendix H) they plan a design, do any required research to help them when designing, select materials and complete a labeled diagram of their final design <p>Performing and Recording</p> <ul style="list-style-type: none"> • Students gather materials • Build their design and record any challenges

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<p>throughout the process.</p> <p>4. Use probing questions and give feedback as required to assist student thinking and problem solving.</p> <p>Sample accommodations:</p> <ul style="list-style-type: none"> Teachers may wish to assist students by providing them with examples of the two rides (roller coaster, ferris wheel) Canada's Wonderland Virtual Coaster Rides Teachers may wish to specify the materials to be used 	<p>or changes that they encountered</p> <ul style="list-style-type: none"> Test their designs and record the results <p>Analysing and Interpreting</p> <ul style="list-style-type: none"> Identify where their ride was successful or unsuccessful. Suggest ways in which the design could be improved to make it successful Students adjust their design if required, retest and record the results of the second test. Identify how the changes they made were successful or unsuccessful and why <p>Communicating</p> <ul style="list-style-type: none"> Prepare an oral presentation introducing their new ride. The presentation should contain an explanation of the process they used to create their ride and a demonstration of the function of their ride and connection between their ride and the environmental impact of building it in real life
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Opportunities for assessment (Links to assessment pieces, organizers):

- On-going assessment of learning through conferences with students as they work through the Design Process
- Rubric for completed model of the ride and the presentation (refer to Appendix J)

Cross Curricular Opportunities:

Language - Oral Communication

Overall:

2. use speaking skills and strategies appropriately to communicate with different audiences for a variety of purposes

Specific:

2.2 demonstrate an understanding of appropriate speaking behaviour in a variety of situations, including paired sharing, dialogue, and small- and large group discussions

2.3 communicate orally in a clear, coherent manner, presenting ideas, opinions, and information in a readily understandable form

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2.4 use appropriate words and phrases from the full range of their vocabulary, including inclusive and non-discriminatory language, and stylistic devices suited to the purpose, to communicate their meaning accurately and engage the interest of their audience

2.7 use a variety of appropriate visual aids (e.g., posters, charts, maps, globes, computer-generated organizers) to support or enhance oral presentations

Mathematics - A number sense and numeration component could be added by asking students to “purchase” materials, based on a budget and specific cost for materials.

Number Sense and Numeration

- round decimal numbers to the nearest tenth, in problems arising from real-life situations

- read and write money amounts to \$1000

- add and subtract decimal numbers to hundredths, including money amounts, using concrete materials, estimation, and algorithms

References:

Byrne, E., Alonzo, T., & Quagliotto, L. (2001, October). *Sturdy Structures: Structures and Mechanisms*. <https://Library.Queensu.ca/Files/Ocup/SturdySt.Pdf>.

Western University. (n.d.). *STEM @ Home*.

<https://www.eng.uwo.ca/outreach/pre-university-programs/stem-home.html>.

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Appendix H

Design Challenge Packet



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Challenge:

Your town is getting a new amusement park! The city planners have asked for a presentation outlining a design for a new ride for the park. Your job is to design a **working** model of either a rollercoaster OR a ferris wheel, build the model and test the model. After your model is built and tested you must sell it to the city planners in your presentation. Your presentation must

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be 3 - 5 minutes in length and include the name of your ride, how you arrived at the design, how you overcame any challenges while building and a demonstration of your working model. While designing your working model be sure to be aware of the ride requirements (see below). Your model must fit on a piece of bristol board.

Roller Coaster: if you choose the roller coaster your coaster must move the people riding the coaster in 4-6 different ways (up, down, left, right, side-to-side, in a circle, etc.).

Ferris Wheel: Your ferris wheel must move the riders at least 1 full turn (360°) without turning the riders upside down, they must remain in a seated position.

Define the problem:

What is the problem you are trying to solve? Consider the following questions: What strategies will you use to ensure that you build a ride that meets the requirements? What function is your device intended to perform?

Do you think you need to do any background research to help you learn more about the problem? What might you need to learn? Where will you find the information?

Are there any further questions you have?

Are there any design requirements that your solutions to the problem must meet? What are they?

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What materials are available for you to use?

Brainstorm:

Brainstorm several ideas to solve the problem below. Include diagrams and labels where you think that would help someone understand your idea. Consider the following questions as you brainstorm: How will you test your structure or device? What safety measures do you need to consider when building and testing it? How will you know if your structure or device was successful?

Idea 1

Idea 2

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Idea 3

Idea 4

Idea 5

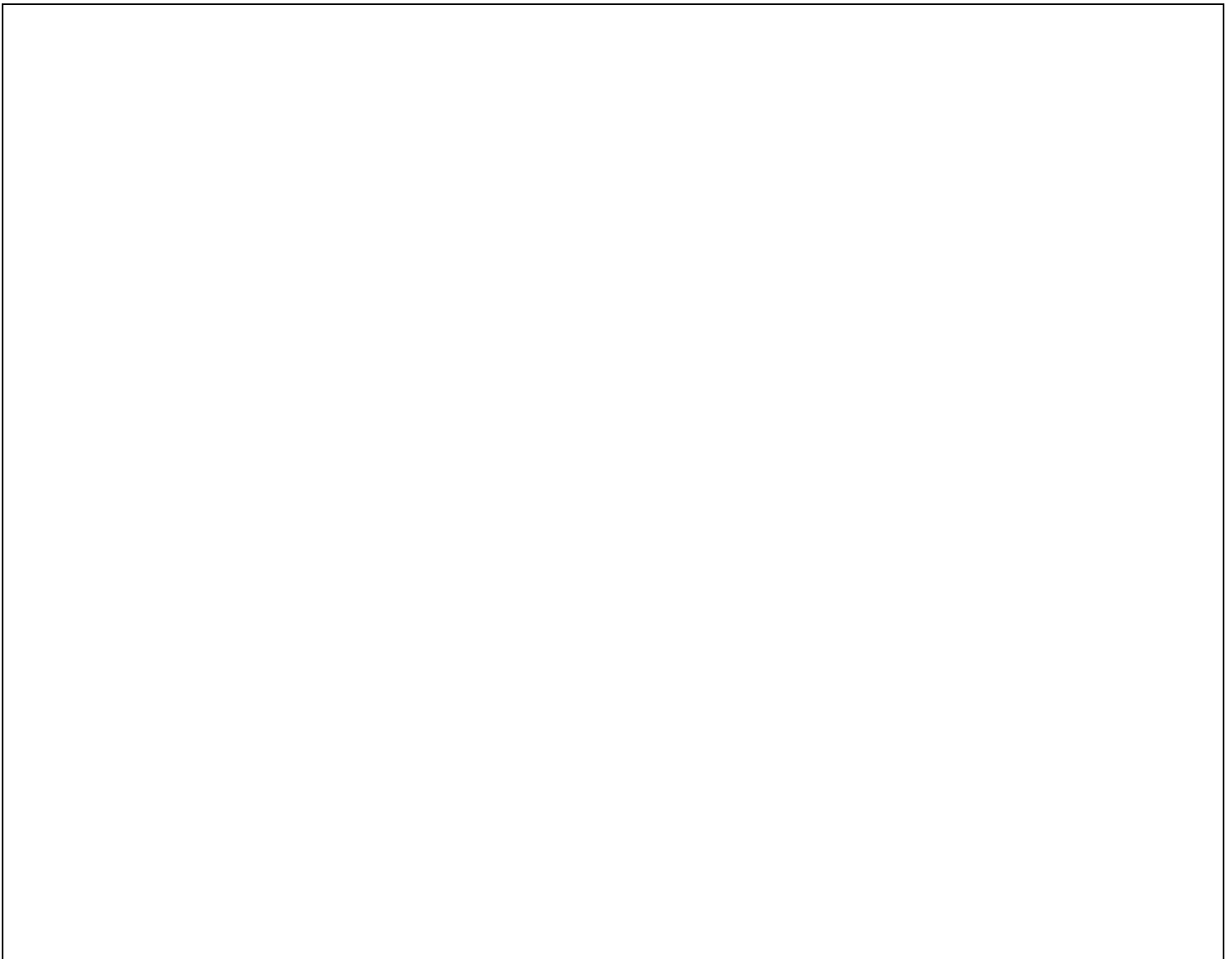
Select:

Evaluate each of your ideas by asking yourself "What are the best parts of the design? What are the possible weaknesses of the design?" After evaluating each idea, select the one you think will best solve the problem and meet the challenge. Record your choice below and explain why you have selected that idea.

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In the space below draw and label a diagram of your design and list the materials you will need to build it.



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Prototype:

Build your structure. Record below any challenges or changes you made to your original design as you built it.

Test:

Test your structure. After you have tested, answer the following questions.

Did your structure perform in the way you thought it would? Why or why not?

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What parts of your structure performed as you had hoped? Why do you think they worked well?

What parts of your structure failed? How would you want to change or improve it if you could develop a new idea?

Make any improvements to your structure that you think will help it perform better during testing. Record those changes below.

Test your structure again. What were the results of the second test? Did your changes improve the strength of your structure?

Communicate:

You may use the answers to the questions below in your presentation to the city council.

My design was effective in meeting the challenge because....

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One challenge that I faced in the construction of my final design was...

I solved this problem by taking the following steps...

The overall effectiveness of my solution to this problem in the final testing of my product was...

Looking back, another way to resolve this problem would have been...

Something I learned from participating in this design challenge is...

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Understanding Mechanical Systems and Force:

Where have you seen some of the different mechanical systems that you have learned about in this activity in other amusement park rides? (In your explanation, think of how the combination of structures and mechanical systems are helpful in supporting a load, increasing or decreasing forces and in moving objects.)

Making Connections:

While researching/learning about amusement park rides, what materials were they made of? How does the use of those materials affect the environment? How could your ride be made with a more sustainable material?

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Appendix I

Forces Acting On Structures Design Challenge - Amusement Park Ride Success Criteria

- I have chosen a ride (roller coaster or ferris wheel) to design, build and test that meets the specified requirements.
- I have completed any additional research for my chosen ride.
- I have had at least 2 conferences with my teacher to discuss my progress.
- I have completed the Design Challenge packet instructions and questions completely and thoroughly.
- I have prepared a 3-5 min. oral presentation to sell my ride which includes an explanation of the process I used to create my ride, a demonstration of the function of my ride and a connection between my ride and the environmental impact of building it in real life.

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Appendix J

Forces Acting on Structures - Design Challenge Amusement Park Ride

- analyse social and environmental impacts of forces acting on structures and mechanisms
- explain the advantages and disadvantages of different types of mechanical systems
- use scientific inquiry/research skills to investigate how structures are built to withstand forces
- use technological problem-solving skills to design, build, and test a frame structure that will withstand the application of an external force

Expectation	Level 1	Level 2	Level 3	Level 4
Thinking and Investigation: 2.3 use scientific inquiry/research skills to investigate the advantages and disadvantages of mechanical systems	-uses processing skills and/or strategies with limited effectiveness	-uses processing skills and/or strategies with some effectiveness	-uses processing skills and/or strategies with considerable effectiveness	-uses processing skills and/or strategies with a high degree of effectiveness
Application 2.4 use technological problem-solving skills to design, build, and test a frame structure) that will withstand the application of an external force or a mechanical system that performs a specific function	-applies knowledge and/or skills in familiar contexts with limited effectiveness	-applies knowledge and/or skills in familiar contexts with some effectiveness	-applies knowledge and/or skills in familiar contexts with considerable effectiveness	-applies knowledge and/or skills in familiar contexts with a high degree of effectiveness
Thinking and Investigation -plan effectively prior to building	-uses planning skills and/or strategies with limited effectiveness	-uses planning skills and/or strategies with some effectiveness	-uses planning skills and/or strategies with considerable effectiveness	-uses planning skills and/or strategies with a high degree of effectiveness
Thinking and Investigation -uses creative thinking and effective strategies to solve building problems	-uses critical/creative thinking processes, skills, and/or strategies with limited effectiveness	-uses critical/creative thinking processes, skills, and/or strategies with some effectiveness	-uses critical/creative thinking processes, skills, and/or strategies with considerable effectiveness	-uses critical/creative thinking processes, skills, and/or strategies with a high degree of effectiveness

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<p>Communication 2.5 use appropriate science and technology vocabulary, including tension, compression, torque, system, and load, in oral and written communication</p>	<p>uses conventions, vocabulary, and terminology of the discipline with limited effectiveness</p>	<p>uses conventions, vocabulary, and terminology of the discipline with some effectiveness</p>	<p>uses conventions, vocabulary, and terminology of the discipline with considerable effectiveness</p>	<p>uses conventions, vocabulary, and terminology of the discipline with a high degree of effectiveness</p>
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