Grade 7

Cluster 3: Forces and Structures

Overview

In this cluster, students explore a variety of natural and human-built structures, and the forces that act on them. Students investigate internal and external forces acting on structures and recognize that these forces may affect structural strength and stability. Students identify common shapes used to increase strength and stability in structures, and methods used to enhance the strength of the materials used. The efficiency of a structure is assessed by comparing its mass with the mass of the load it supports. Students apply their understanding of forces and structures by evaluating the appropriateness of a specific structure's design, and by constructing a structure of their own that supports a given load and remains standing when a particular force is applied.

PRESCRIBED LEARNING OUTCOMES
Students will...
7-3-01 Use appropriate vocabulary related to their investigations of forces and structures. Include: frame, shell, solid, centre of gravity, stability, compression, tension, shear, torsion, internal and external forces, stress, structural fatigue, structural failure, load, magnitude, point and plane of application, efficiency. GLO: C6, D4

SUGGESTIONS FOR INSTRUCTION

Teacher Notes

Prior Knowledge

Students have had previous experiences related to forces in Grade 6, Cluster 2: Flight, and in Grade 5, Cluster 3: Forces and Simple Machines.

➢ Introduce, explain, use, and reinforce vocabulary throughout this cluster.

➢ **Three-Point Approach**

Have students use the Three-Point Approach (Simons, 1991) to write a definition of a term in their own words, represent it with a picture/diagram, and give an example or synonym.

(For a BLM of the Three-Point Approach for Words and Concepts, see *SYSTH*, Attachment 10.2, or *Success*, p. 6.101.)

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

PRESCRIBED LEARNING OUTCOMES

Students will...

7-3-02 Classify natural and human-built structures found locally and around the world.

Include: frame, shell, solid.

GLO: E1

7-0-2a ⊂ Access information using a variety of sources. *Examples: libraries, magazines, community resource people, outdoor experiences, videos, CD-ROMs, Internet…* GLO: C6 (ELA Grade 7, 3.2.2; TFS 2.2.1)

7-0-5a ⊂ Make observations that are relevant to a specific question. GLO: A1, A2, C2

7-0-5f Record, compile, and display observations and data, using an appropriate format. GLO: C2, C6 (ELA Grade 7, 3.3.1; Math: SP-III.2.7)

7-0-7f ⊂ Reflect on prior knowledge and experiences to construct new understanding and apply this new knowledge in other contexts. GLO: A2, C4 (ELA Grade 7, 1.2.1)

SUGGESTIONS FOR INSTRUCTION

➢ Classifying Structures According to Design

Provide students with pictures (from pamphlets, travel brochures, or magazines) of the three types of structures: solid, frame, and shell.

Examples:

- *solid*: Great Wall of China, castle, dam, cliffs along the sea, iceberg
- *frame*: house (frame), tower, umbrella, stairway, skeleton
- *shell*: quinzhee, tent, ball, wasp nest, cocoon, freshwater clam shell, canoe, tipi

Using a Sort and Predict strategy (Brownlie and Close, 1992), have students

- sort the pictures of structures into categories
- create category names to identify characteristics of the different types of structures. Explain to students the terms *solid*, *frame*, and *shell*, and ask them whether they categorized their samples in a similar fashion.

Note: Students may have put structures that were combinations of structure types in the fourth category or the Sort and Predict sheet. Many structures are actually combinations of types. Have students identify the structure types within the combinations.

(For a BLM of the Sort and Predict strategy, see *SYSTH*, Attachment 10.3; *Success*, p. 6.100.)

➢ Structure Walk

Have the class walk through the neighbourhood to identify various structures and structure types. Ask students to answer the following questions in their science notebooks:

1. Fill in the following chart with examples you saw on the structure walk:

Solid Structure	Frame Structure	Shell Structure

2. Did you observe any structures that were a combination of two types? If so, identify the structures and the types involved in their construction.
3. What type of structure is the human body? Explain.

Suggestions for Assessment

Suggested Learning Resources

Restricted Response

Provide students with the following:

Classifying Structures: Solid, Frame, or Shell?

Identify the following as solid, frame, or shell structures.

1. stone bridge
2. igloo
3. Eiffel Tower
4. dam
5. staircase

Look for:

1. solid
2. shell
3. frame
4. solid
5. frame

Teacher Notes

Background Information

- *Solid structures* are made of solid piece(s) of strong material (e.g., a stone bridge).
- *Frame structures* are made of parts connected into a set arrangement (e.g., framing for a house).
- *Shell structures* are moulded into a shape that provides strength and stability (e.g., a basketball).

Nelson Science & Technology 7 (Section 3.13)

Sciencepower 7 (Section 13.1)

Addison Wesley Science & Technology 7 (Chapter 4, Sections 1.2-1.4)

PRESCRIBED LEARNING OUTCOMES

Students will...

7-3-03 Identify the centre of gravity in a model structure, and demonstrate that changes in the location of a structure's centre of gravity affect its stability.

GLO: C1, D4

7-0-3a Formulate a prediction/hypothesis that identifies a cause and effect relationship between the dependent and independent variables. GLO: A2, C2 (Math: SP-I.1.7)

7-0-4c ⊂ Work cooperatively with team members to carry out a plan, and troubleshoot problems as they arise. GLO: C7 (ELA Grade 7, 5.2.1)

7-0-4d ⊂ Assume various roles to achieve group goals. GLO: C7 (ELA Grade 7, 5.2.2)

7-0-5a ⊂ Make observations that are relevant to a specific question. GLO: A1, A2, C2

7-0-7h Identify and evaluate potential applications of investigation results. GLO: C4

(continued)

SUGGESTIONS FOR INSTRUCTION

➢ Identifying the Centre of Gravity

Part A

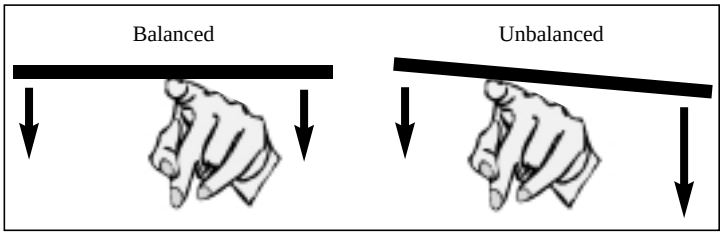
Have students balance a ruler with one finger and record where their finger is placed along the length of the ruler. Then have students place their finger towards one end of the ruler and observe what happens.

Ask students to answer the following questions in their science notebooks:

1. Where along the length of the ruler did you place your finger to balance the ruler? (the middle)
2. What force was pulling on the ends of the ruler? (gravity)
3. Your finger, pushing on the ruler, counteracted the pull of gravity only when the force of gravity was divided equally on either side of the ruler. Draw two force diagrams using arrows to illustrate the forces when the ruler was balanced and when it was not.

   Example:

Force Diagrams



4. The balancing point you found with the ruler is called the centre of gravity, the object's most stable point. Draw a 10 cm circle on a piece of cardboard and cut it out. Predict and then test to determine where the centre of gravity is located so that you can balance the circle on your fingertip. Record your observations. Create a variety of shapes and try to find the balancing point for each.

Part B

Have pairs of students connect one end of a string to the buckle of a belt that one partner is wearing, and the other end of the string to a large washer which should hang at knee level on the person wearing the belt. The partner wearing the belt will be asked to stand straight in four positions:

- with feet together
- with feet slightly apart

(continued)

Suggestions for Assessment

Suggested Learning Resources

Teacher Notes

Background Information

- The direction and strength of a force is represented by arrows called *vectors*. A longer arrow represents a stronger force. The point of the arrow shows the direction in which the force is being applied.
- Pairs of forces are usually included in force diagrams and it is possible to predict the effects of forces by comparing their relative size.
- Force diagrams are drawn for a particular purpose and may not be a true representation of how a force is acting on an object. For example, even though gravity is acting on all parts of a structure we may use one arrow to illustrate its relative strength.
- Identifying forces acting on structures is a complex task. The emphasis should be on direction and relative strengths of forces as opposed to exact placement of vector arrows.

Nelson Science & Technology 7 (Section 3.13)

Sciencepower 7 (Section 15.2)

Addison Wesley Science & Technology 7 (Chapter 4, Section 2.1)

PRESCRIBED LEARNING OUTCOMES	SUGGESTIONS FOR INSTRUCTION
Students will...	
7-3-03 *(continued)*	*(continued)*

- with feet shoulder-width apart, and knees bent
- on one foot

Ask students to record their predictions of where the washer will be located in each stance/position. Then have the belted partners assume each of the four positions and attempt to reach for something in front of them without moving their feet. Have students observe and record the position of the washer at the point at which balance is lost or almost lost.

After the demonstration, ask students to answer the following questions in their science notebooks:

1. What was the position of the washer in relation to the student's feet and hips when he or she lost balance? (It was no longer lined up with the student's feet and hips.)
2. The centre of gravity of a person is located in the mid-abdomen region, over the hips. Where must the centre of gravity be in relation to your feet for you to remain balanced while standing? (The centre of gravity must remain between your feet.)
3. a. Of the four demonstrated stances/positions, which one provided the most stability? (the third stance) why? (because the centre of gravity was between the student's feet and lower to the ground)
   b. Test your previous answer by having your partner take the same set of positions again, but this time try to push him or her over with one hand.
   c. Was your prediction correct? If not, which position was found to be the most stable? Explain why.
   d. How is this knowledge of stability, balance, and centre of gravity used in sports? (It is used in the stance of defensive football players so that the opposing team will not push the players over. It is used in the stance of volleyball players receiving a bump so that they can withstand the force of the ball without losing their balance. It is used in the stance of a hockey goalie so that he or she can stretch to the puck without losing balance.)

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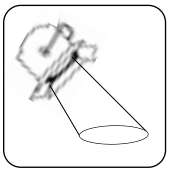
SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

PRESCRIBED LEARNING OUTCOMES	SUGGESTIONS FOR INSTRUCTION
Students will...	
7-3-03 *(continued)*	*(continued)* ➢ **Tower-Building Contest** Have groups of students participate in a contest to build the tallest free-standing structure with blocks or dominoes (not interlocking) in a given period of time. This can be done at a station with poster paper on the wall, so that teams can mark off their tower height. Ask students to follow these guidelines: • Prior to building, create a plan for your tower. • Decide, as a class, the time limit allowed for construction, taking into consideration time allowed for "stability checks." • During construction, you may not modify the structure once the blocks are in place. However, you may modify your plans for subsequent layers. • The structure must be stable for a 10-second count, so you may wish to conduct stability checks as you build. You should record the height you achieved at each stability check. • Draw your final structure and record the height on the poster paper. After all groups have completed the tower construction, compare diagrams and heights and have students answer the following questions: 1. What similarities in structure were found among the shortest towers? (a narrow base) 2. What was the common characteristic of the taller towers? (a wide base) 3. Using the terms *stability* and *centre of gravity,* describe what is needed to ensure that a tall tower is stable. (It needs to have a wide base so that the centre of gravity lies within the area of the base and can provide stability for all the blocks above.)

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES



Balance, Force, and Centre of Gravity Investigation

Have students, working in pairs, take turns sitting on a chair and then standing up without using their hands.

Note: Having students work with same-sex partners for this learning activity may relieve the self-consciousness this age group may experience while observing body actions.

Have one partner sit in a chair while the other partner stands in front of the chair, placing his or her outstretched hand on the seated partner's forehead. Ask the seated partner to attempt to stand up. The standing partner should not move or bend his or her arm as the seated partner attempts to stand up from the chair. The standing partner should not use undue force in preventing the seated partner from standing, but should keep the seated partner from passing a certain plane. Have students change roles and repeat the experiment.

Example:

Ask students to answer the following question in their science notebooks, using the terms *balance, force,* and *centre of gravity*: Why is it difficult to stand up from the seated position with a person's hand on your forehead?

Look for:

It is difficult because the student is unable to bend forward. To achieve balance when rising from a sitting position we lean forward to shift our centre of gravity over our feet, which will support us when we stand. Having a partner restrict our movement when rising prevents us from overcoming the force of gravity.

Scoring Rubric	
Score	**Criteria**
3	The explanation uses the terms *balance*, *force*, and *centre of gravity* appropriately and shows an understanding of the concepts.
2	The explanation uses two of the three terms appropriately and shows an understanding of the concepts stated.
1	The explanation has one or fewer terms used appropriately.

PRESCRIBED LEARNING OUTCOMES

Students will...

7-3-04 Identify internal forces acting on a structure, and describe them using diagrams.

Include: compression, tension, shear, torsion.

GLO: D4, E4

7-0-4c ⊂ Work cooperatively with team members to carry out a plan, and troubleshoot problems as they arise. GLO: C7 (ELA Grade 7, 5.2.1)

7-0-4d ⊂ Assume various roles to achieve group goals. GLO: C7 (ELA Grade 7, 5.2.2)

7-0-5a ⊂ Make observations that are relevant to a specific question. GLO: A1, A2, C2

7-0-7f ⊂ Reflect on prior knowledge and experiences to construct new understanding and apply this new knowledge in other contexts. GLO: A2, C4 (ELA Grade 7, 1.2.1)

7-0-7g ⊂ Communicate methods, results, conclusions, and new knowledge in a variety of ways. *Examples: oral, written, multimedia presentations...* GLO: C6 (ELA Grade 7, 4.4.1)

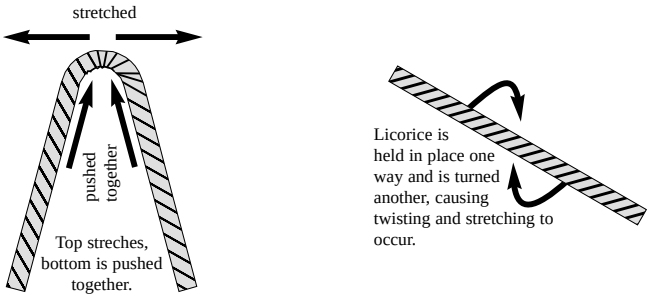
SUGGESTIONS FOR INSTRUCTION

➢ Observing the Effects of Forces

Provide students with licorice strips. To help students observe the effects of forces, ask them to complete the following:

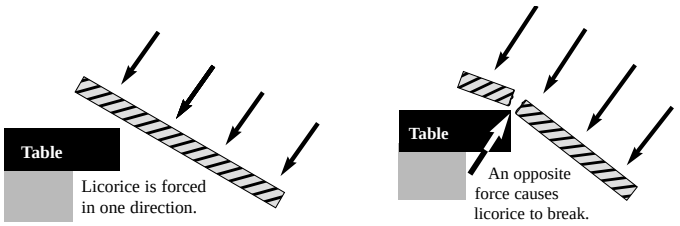
1. Bend a licorice strip in half and observe where the bend occurs. In your science notebook, draw a diagram of the licorice and label the top and the bottom part of the bend with arrows to indicate the direction of the forces acting within the licorice. Write a brief description of what is happening.
2. Straighten the licorice and, holding one end steady, turn the other end of the licorice. In your science notebook, draw a diagram of the licorice and label the directional forces. Write a brief description of what is happening.

   Example:



Demonstration: Break frozen licorice against the edge of a table. Be sure to wear safety goggles and have students at a safe distance. Show students the pieces. Have them draw the licorice, label the directional forces, and describe their observations in their science notebooks.

Example:



Ask students to identify which licorice example best illustrates the following:

- *Compression* is the result of forces squeezing together. (bottom of bent licorice)
- *Tension* is the pulling apart of a structure. (top of bent licorice)
- *Shear* is the result of forces acting in opposite directions of each other. (broken licorice)
- *Torsion* is a twisting force. (twisted licorice)

SUGGESTIONS FOR ASSESSMENT	SUGGESTED LEARNING RESOURCES
Refer to the assessment strategy suggested for learning outcome 7-3-08.	*Nelson Science & Technology 7* (Section 3.12) *Sciencepower 7* (Section 14.3) *Addison Wesley Science & Technology 7* (Chapter 4, Section 2.4)

PRESCRIBED LEARNING OUTCOMES

Students will...

7-3-05 Identify external forces acting on a structure, and describe them using diagrams.

Examples: snow on a rooftop, wind on a tent, water against a beaver dam...

GLO: C6, D4, E4

7-0-4c ⊂ Work cooperatively with team members to carry out a plan, and troubleshoot problems as they arise. GLO: C7 (ELA Grade 7, 5.2.1)

7-0-4d ⊂ Assume various roles to achieve group goals. GLO: C7 (ELA Grade 7, 5.2.2)

7-0-5a ⊂ Make observations that are relevant to a specific question. GLO: A1, A2, C2

7-0-7g ⊂ Communicate methods, results, conclusions, and new knowledge in a variety of ways. *Examples: oral, written, multimedia presentations...* GLO: C6 (ELA Grade 7, 4.4.1)

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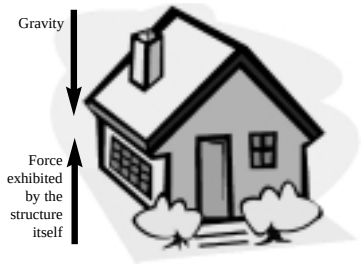
SUGGESTIONS FOR INSTRUCTION

➢ External Forces

Part A

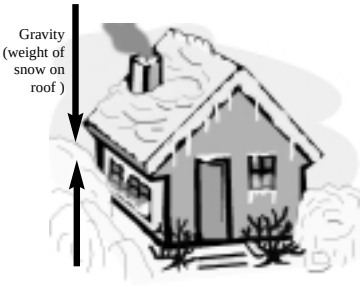
Using a Think-Pair-Share strategy (McTighe and Lyman, 1992), have students brainstorm the external forces that act on the structure of a house. Show students a diagram of what those forces are and how to identify them on a diagram, noting that gravity and the force exhibited by the structure itself are equal and thus balanced. Inform students that force diagrams usually show pairs of forces.

Example:



Now change the scenario slightly by adding the weight of a heavy snowfall onto the house. Ask students what the size of the arrow signifying gravity would be now in relation to the previous diagram. (It would be longer.)

Example:



Have students answer the following questions in their science notebooks:

1. If the snow-covered house represented in the second diagram were to remain standing, what would the force exhibited by the structure of the house have to be in relation to the force of gravity? (It would be the same as the force of gravity.)
2. What would happen if there was too much snow on the house? How would you picture this using a force diagram? (The house would collapse. The picture drawn should show some collapse and the arrow indicating the force of gravity should be longer than the one representing the force exhibited by the house.)

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SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

Nelson Science & Technology 7 (Section 3.21)

Sciencepower 7 (Section 14.3)

Addison Wesley Science & Technology 7 (Chapter 4, Section 2.1)

PRESCRIBED LEARNING OUTCOMES	SUGGESTIONS FOR INSTRUCTION
Students will...	
7-3-05 *(continued)*	*(continued)*

3. Why do engineers have to take these concepts of force into consideration when designing and building a structure? (Because the structure could fail, people could be hurt, and property could be damaged.)

Part B

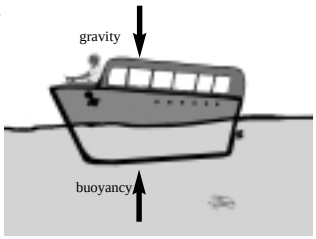
Have students create force diagrams identifying the forces in the following scenarios about a boat. Inform students that the force acting to keep the boat up is called *buoyancy*. When students have completed their force diagrams, review them with the class.

Examples:

1. The boat is floating in one place on a calm lake.
2. The boat gets caught in a current of water that begins to move it backwards.
3. The driver starts the motor and goes against the current.

   (**Note:** Students may not know that the motor works on the basis of one of Newton's laws. The important aspect is that the ultimate force of the motor overpowers the force of the current.)
4. The driver has picked up 10 people at the dock and the boat is sitting a little lower in the water.

1.



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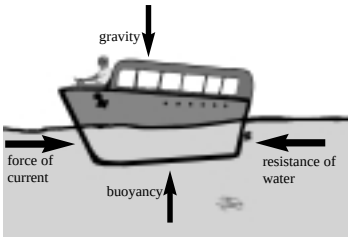

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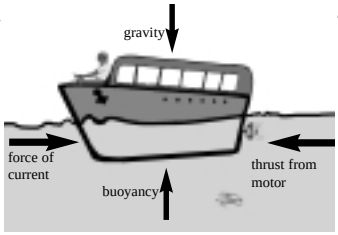

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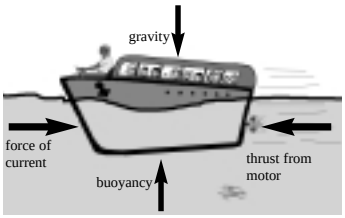

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Suggestions for Assessment

Suggested Learning Resources

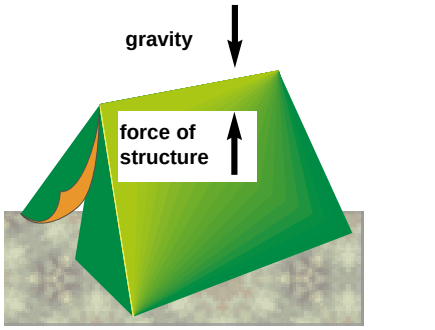
Restricted Response

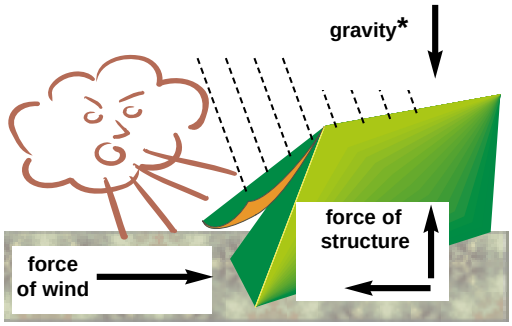
Provide students with the following:

Force Diagram

Draw a force diagram detailing the forces acting on a tent or tipi before and during a summer storm. The diagram should indicate opposing forces (during the summer storm), and, if the arrows are unbalanced, the structure (tent) should show signs of collapse.

Look for:





(* The weight of the tent fabric increased because rain caused gravitational pull to increase.)

Prescribed Learning Outcomes

Students will...

7-3-06 Recognize that internal and external forces apply stress to structures, and describe examples in which this stress has led to structural fatigue or structural failure.

GLO: D4, E3

7-0-2a ⊂ Access information using a variety of sources. *Examples: libraries, magazines, community resource people, outdoor experiences, videos, CD-ROMs, Internet…* GLO: C6 (ELA Grade 7, 3.2.2; TFS 2.2.1)

7-0-2c Make notes using headings and subheadings or graphic organizers appropriate to a topic and reference sources. GLO: C6 (ELA Grade 7, 3.3.2)

7-0-7g ⊂ Communicate methods, results, conclusions, and new knowledge in a variety of ways. *Examples: oral, written, multimedia presentations...* GLO: C6 (ELA Grade 7, 4.4.1)

Suggestions for Instruction

Teacher Notes

Background Information

- *Structural stress* occurs when a combination of external and internal forces act on a structure at one time.
- *Structural fatigue* occurs when a combination of external and internal forces weakens components of a structure (e.g., weakening of beams or concrete).
- *Structural failure* occurs when the structure itself collapses.

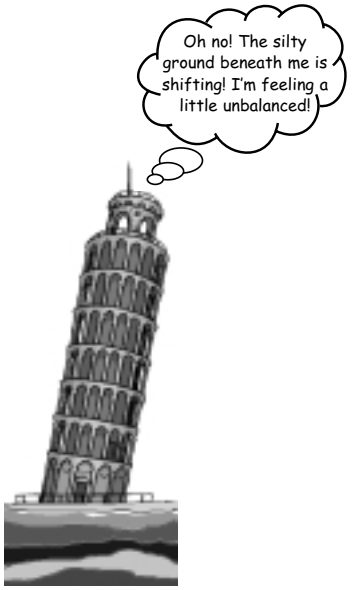
➢ Tower of Pisa Comic Strip

Have pairs of students read the article "Anti-gravity in Pisa" (BLM 7-F). In reading this text, students will need to use reading comprehension strategies such as partner reading, SQ3R, or structured note taking. (See *5-8 ELA*, learning outcome 2.1.2.)

It would be helpful for students to insert subheadings into the article, depicting the major undertakings to correct the lean, over time.

Have students

- create, in storyboard/comic strip fashion, a series of pictures that depict the internal and external forces that have caused the structural stress to occur and the attempts to correct it
- include brief captions or speech bubbles that provide textual information to support each concept



Example

➢ Structural Fatigue

Working in groups, have students

- research print and electronic multimedia resources to find other examples of structures that show signs of structural fatigue and/or failure
- identify the internal and external forces adding to the structural stress causing fatigue or failure, and explain what happened
- present their information in a labelled poster to be displayed in a gallery or bulletin board display

SUGGESTIONS FOR ASSESSMENT

Tower of Pisa Comic Strip

Provide students with the following tool for peer assessment of the Tower of Pisa comic strip:

Peer Assessment of Comic Strip

Comic strip author: _____

Peer assessor: _____

Criteria	Poor		Good		Excellent
The comic strip					
• shows creativity	1	2	3	4	5
• clearly illustrates major stages	1	2	3	4	5
Constructive comment:					

SUGGESTED LEARNING RESOURCES

Nelson Science & Technology 7 (Sections 3.8-3.10)

Sciencepower 7 (Sections 14.3, 15.1)

Addison Wesley Science & Technology 7 (Chapter 4, Sections 2.6-2.7)

Prescribed Learning Outcomes

Students will...

7-3-07 Investigate to determine that the effect of a force on a structure depends on its magnitude, direction, and point and plane of application.

GLO: D4

7-0-1a ⊂ Formulate specific questions that lead to investigations. Include: rephrase questions to a testable form; focus research questions. GLO: A1, C2 (ELA Grade 7, 3.1.2; Math: SP-I.1.7)

7-0-3a Formulate a prediction/hypothesis that identifies a cause and effect relationship between the dependent and independent variables. GLO: A2, C2 (Math: SP-I.1.7)

7-0-3b Identify with guidance the independent and dependent variables in an experiment. GLO: A2, C2

7-0-3c Create a written plan to answer a specific question. Include: apparatus, materials, safety considerations, steps to follow, and variables to control. GLO: C2 (ELA Grade 7, 3.1.4)

7-0-4a Carry out procedures that comprise a fair test. Include: controlling variables, repeating experiments to increase accuracy and reliability. GLO: C2

7-0-4e Demonstrate work habits that ensure personal safety, the safety of others, and consideration for the environment. Include: keeping an uncluttered workspace; putting equipment away after use; handling glassware with care; wearing goggles when required; disposing of materials safely and responsibly. GLO: C1

7-0-5a ⊂ Make observations that are relevant to a specific question. GLO: A1, A2, C2

7-0-5c Select and use tools to observe, measure, and construct. Include: microscopes, a variety of thermometers, graduated cylinders, glassware, balance. GLO: C2, C3, C5

7-0-5e Estimate and measure accurately using SI and other standard units. Include: determining volume by displacement of water. GLO: C2, C5 (Math: SS-IV.1.6, SS-III.1.5, SS-III.1.6, SS-I.1.5)

7-0-5f Record, compile, and display observations and data, using an appropriate format. GLO: C2, C6 (ELA Grade 7, 3.3.1; Math: SP-III.2.7)

7-0-6a Construct graphs to display data, and interpret and evaluate these and other graphs. Examples: frequency tallies, histograms, double-bar graphs, stem-and-leaf plots… GLO: C2, C6 (ELA Grade 7, 3.3.1;Math: SP-III.2.6; TFS: 4.2.2– 4.2.6)

7-0-6b Interpret patterns and trends in data, and infer and explain relationships. GLO: A1, A2, C2, C5

Suggestions for Instruction

➢ Spaghetti Beam Bridge

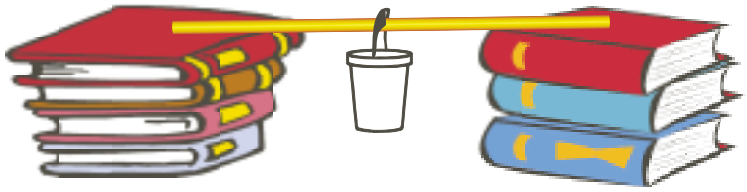
Have students conduct an experiment to determine whether the magnitude of weight needed to cause structural failure of a "spaghetti bridge" (see diagram below) differs at various points along the plane of a bridge. Have students record their work on the "Experiment Report" (BLM 7-Q).

For this experiment, ask students to

- identify the independent variable (point of application of load force) and dependent variable (magnitude of weight)
- discuss, as a class, some of the controlled variables that need to be addressed (e.g., type of spaghetti, number of strands, type of elastic bands to hold spaghetti together, types of masses used)
- develop a hypothesis, list of materials needed, and method
- chart or graph the magnitude versus the point of application
- develop a conclusion based on their data. The conclusion should show the relationship between magnitude of weight and point of application, and also identify the strongest and weakest points along the plane of the bridge.

Example:

Note: A basket may be used to add mass to the bridge. The basket could be filled with objects such as pennies, weights, or sand.



7-0-6c Identify strengths and weaknesses of different methods of collecting and displaying data, and potential sources of error. GLO: A1, A2, C2, C5 (ELA Grade 7, 3.3.3)

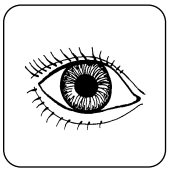
7-0-6f Identify how the original plan evolved and justify the changes. GLO: C2, C3 (ELA Grade 7, 3.3.4)

7-0-7a Draw a conclusion that explains investigation results. Include: explaining the cause and effect relationship between the dependent and independent variables; identifying alternative explanations for observations; supporting or rejecting a prediction/hypothesis. GLO: A1, A2, C2 (ELA Grade 7, 3.3.4)

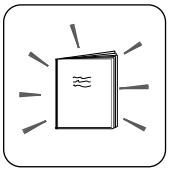
7-0-9c ⊂ Demonstrate confidence in their ability to carry out investigations. GLO: C5

SUGGESTIONS FOR ASSESSMENT

Refer to the following BLMs for assessment suggestions:



"Conducting a Fair Test: Observation Checklist" (BLM 7-P)



"Experiment Report: Assessment" (BLM 7-R)

Also refer to the assessment strategy suggested for learning outcome 7-3-08.

SUGGESTED LEARNING RESOURCES

Nelson Science & Technology 7 (Section 3.14)

Sciencepower 7 (Section 15.1)

Addison Wesley Science & Technology 7 (Chapter 4, Section 2.6)

PRESCRIBED LEARNING OUTCOMES

Students will...

7-3-08 Describe, using diagrams, how common structural shapes and components can increase the strength and stability of a structure.

Examples: a triangle distributes the downward force of a load evenly between its two vertices...

GLO: C6, D3, D4

7-0-4c ↻ Work cooperatively with team members to carry out a plan, and troubleshoot problems as they arise. GLO: C7 (ELA Grade 7, 5.2.1)

7-0-4d ↻ Assume various roles to achieve group goals. GLO: C7 (ELA Grade 7, 5.2.2)

7-0-5f Record, compile, and display observations and data, using an appropriate format. GLO: C2, C6 (ELA Grade 7, 3.3.1; Math: SP-III.2.7)

7-0-7f ↻ Reflect on prior knowledge and experiences to construct new understanding and apply this new knowledge in other contexts. GLO: A2, C4 (ELA Grade 7, 1.2.1)

(continued)

SUGGESTIONS FOR INSTRUCTION

➢ Structure Shape Test

Give groups of students one piece of manila paper each and an equal portion of tape. Have groups predict what shape of structure created with these materials will be able to hold the most books on the top and then have them build their structure. Students may shape their structure into a cylinder or fold it into a box-like or prism shape, but should have minimal overlap of paper. A time limit may be imposed. When the students are finished, test each structure with a set of equally weighted books. As a culmination, have a class discussion about which shape has the most structural strength.

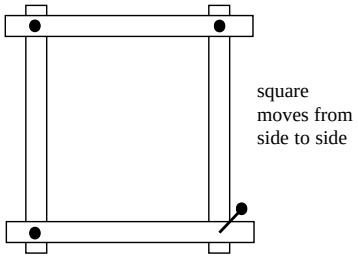
➢ Components That Add Stability

In conducting the "Spaghetti Beam Bridge" learning activity associated with learning outcome 7-3-07, students discovered that the weakest point in a beam bridge is the middle. Have students draw a diagram indicating what they could add to bridges to strengthen them. Have them share their suggestions with the class. Some possibilities are: placing a pillar in the middle, adding arches under the bridge, or adding struts or ties. (Refer to the Teacher Notes on the following page.)

➢ Stable Shapes

Have students make a square using four straws and four straight pins. Ask students to push or pull on the sides of the square and record their observations in their science notebooks.

Example:



Have students

- determine the placement of one more straw to make the square more stable, diagram their results, and identify the shape that brought stability to the square
- determine where a support straw should be placed for a rectangle, diagram their results, and identify the shape that brought stability to the rectangle

(continued)

Suggestions for Assessment

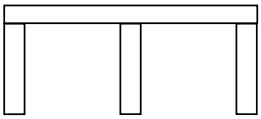
Suggested Learning Resources

Teacher Notes

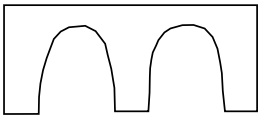
Background Information

The following structures include components that add stability.

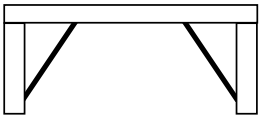
pillars



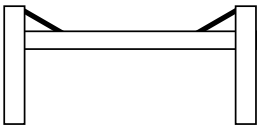
arches



struts



ties



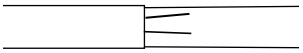
Students may use the following joints for the "Stable Shapes" and "Three-Dimensional Stability" learning experiences suggested for learning outcome 7-3-08.

Joint A

Place a paperclip into the end of one straw and connect it with a second paper clip. Then place the second paper clip into another straw.

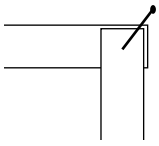
Joint B

Bend one end of a straw and slide it into the end of a second straw.



Joint C

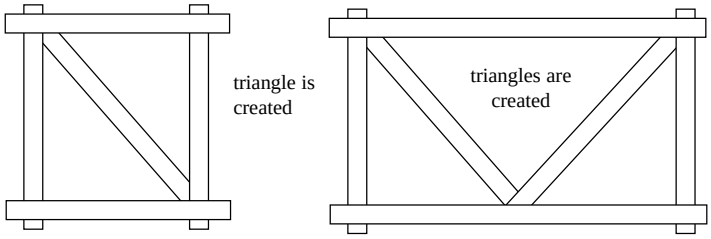
Pin two straws together using a straight pin.



Nelson Science & Technology 7 (Sections 3.17-3.19)

Sciencepower 7 (Sections 14.3, 15.3)

Addison Wesley Science & Technology 7 (Chapter 4, Section 3.1)

PRESCRIBED LEARNING OUTCOMES	SUGGESTIONS FOR INSTRUCTION
Students will...	
7-3-08 *(continued)*	*(continued)* Examples:  ➢ **Three-Dimensional Stability** Have students work in small groups to build the biggest possible frame, using drinking straws, for a clubhouse. The structure must be relatively stable. When students have finished their basic frame, have them predict what structural supports could be added to make the structure even more stable. Then have students add the structural supports, periodically testing for stability. When students are finished constructing their clubhouses, have them answer the following questions: 1. Draw a diagram of one wall of your constructed house. Indicate where you added the structural support and explain why. 2. What main shape did you use to give your clubhouse stability? (a triangle) 3. Square and rectangular structures are not the strongest or most stable structures, but they are easy to make. Engineers have developed adaptations to strengthen these types of structures, including the addition or use of: arches, struts, ties, pillars, trusses, gussets, cantilevers, and braces. Research these terms and record your information using a Three-Point Approach (Simons, 1991). (For a BLM of the Three-Point Approach for Words and Concepts, see *SYSTH*, Attachment 10.2 or *Success*, p. 6.101.)

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

Restricted Response

(Learning outcomes 7-3-04 to 7-3-08)

Provide students with the following:

Forces Acting on Structures

Circle the best answer.

1. A twisting force that acts on structures is called:
   a. torsion
   b. tension
   c. shear
   d. magnitude
2. Forces acting in opposite directions of each other results in:
   a. torsion
   b. tension
   c. shear
   d. magnitude
3. The amount of force applied is called:
   a. torsion
   b. tension
   c. shear
   d. magnitude
4. One spot of paint is to a whole painted wall is point of application is to _____of application.
   a. magnitude
   b. structural fatigue
   c. plane
   d. shear
5. A combination of external and internal forces acting on a structure at one time is called:
   a. structural fatigue
   b. structural stress
   c. structural failure
   d. plane failure
6. A structure that allows for the load force to be transferred along its curves instead of one particular point is called:
   a. strut
   b. gusset
   c. tie
   d. arch
7. Trusses rely on this shape to give them stability:
   a. circle
   b. cube
   c. triangle
   d. arch

Look for:

1. a
2. c
3. d
4. c
5. b
6. d
7. c

PRESCRIBED LEARNING OUTCOMES

Students will...

7-3-09 Describe and demonstrate methods to increase the strength of materials.

Examples: corrugation of surfaces, lamination of adjacent members, alteration of the shape of components...

GLO: C2, C3, D3, E3

7-0-4c ⊂ Work cooperatively with team members to carry out a plan, and troubleshoot problems as they arise. GLO: C7 (ELA Grade 7, 5.2.1)

7-0-5b ⊂ Test a prototype or consumer product, using predetermined criteria. GLO: C3, C5

7-0-6d ⊂ Identify and make improvements to a prototype, and explain the rationale for the changes. GLO: C3, C4

7-0-7f ⊂ Reflect on prior knowledge and experiences to construct new understanding and apply this new knowledge in other contexts. GLO: A2, C4 (ELA Grade 7, 1.2.1)

7-0-7g ⊂ Communicate methods, results, conclusions, and new knowledge in a variety of ways. *Examples: oral, written, multimedia presentations...* GLO: C6 (ELA Grade 7, 4.4.1)

7-0-9d Value skepticism, accuracy, precision, and open-mindedness as scientific and technological habits of mind. GLO: C5

SUGGESTIONS FOR INSTRUCTION

➢ Analyzing Boxes

Provide small groups of students with various types of boxes (e.g., a donut box, a shoe box, a cardboard box) and have them

- identify which boxes are the strongest
- identify the characteristics that make some boxes stronger than other boxes
- record their findings in their science notebooks
- share their observations with the class

Have students focus on the materials used to create the boxes, not on the joints, glue, or staples.

➢ Penny-Paper Bridge

Working in small groups, have students place a piece of paper between two stacks of books to create a beam bridge. Have students place pennies on the bridge until structural failure occurs.

Have students plan and build a paper beam bridge that will hold more pennies than the previous one, following these guidelines:

- The span of the new beam bridge must be the same length as that of the previous one.
- The type of paper used must be the same, but there is no limit on the quantity.
- The paper can be folded (e.g., corrugated).
- Small amounts of tape and glue may be used to create box beams or I-beams as bridge spans.

Have students share their end product with the class, discussing their modifications and how successful they were at increasing the amount of load that the bridge was able to hold.

SUGGESTIONS FOR ASSESSMENT

Refer to "How We Worked Together" (BLM 7-G).

SUGGESTED LEARNING RESOURCES

Nelson Science & Technology 7 (Section 3.15)

Sciencepower 7 (Section 13.2)

Addison Wesley Science & Technology 7 (Chapter 4, Sections 3.2-3.3)

PRESCRIBED LEARNING OUTCOMES

Students will...

7-3-10 Determine the efficiency of a structure by comparing its mass with the mass of the load it supports.

GLO: C1, C5

7-0-1c Identify practical problems to solve. *Examples: How can I keep my soup hot? Which type of sunscreen should I buy?…* GLO: C3

7-0-2a ⊂ Access information using a variety of sources. *Examples: libraries, magazines, community resource people, outdoor experiences, videos, CD-ROMs, Internet…* GLO: C6 (ELA Grade 7, 3.2.2; TFS 2.2.1)

7-0-3d Develop criteria to evaluate a prototype or consumer product. Include: function, aesthetics, environmental considerations, cost, efficiency. GLO: C3

7-0-3e Create a written plan to solve a problem. Include: materials required, three-dimensional sketches, steps to follow. GLO: C1, C3, C6

7-0-4b ⊂ Construct a prototype. GLO: C3

7-0-5b ⊂ Test a prototype or consumer product, using predetermined criteria. GLO: C3, C5

7-0-6d ⊂ Identify and make improvements to a prototype, and explain the rationale for the changes. GLO: C3, C4

7-0-6e ⊂ Evaluate the strengths and weaknesses of a consumer product, based on predetermined criteria. GLO: C3, C4

7-0-7d ⊂ Propose and justify a solution to the initial problem. GLO: C3

7-0-9c ⊂ Demonstrate confidence in their ability to carry out investigations. GLO: C5

SUGGESTIONS FOR INSTRUCTION

➢ **Load Force Capacity Versus Mass of Bridge**

Divide the class into teams of "student engineers." Present each team with the following scenario:

A construction company is looking for a method to build a bridge across a specific span with the least possible amount of materials, but still strong enough to carry a large load force.

Using a set of criteria established with the class (e.g., types of materials, load force, time allotment, span, aesthetics), have each team design and construct a bridge that meets the required specifications. Students may need to conduct background research to investigate types of building materials and bridge design.

Have each team present information related to the mass of its bridge and the mass of the load it supported. Compile the information into a class data table and have students analyze the results. If the bridges vary greatly in mass, the following formula can be used to calculate and compare the structural efficiency of each bridge. Have students identify key features of the bridges that were most efficient.

$$\text{Structural efficiency} = \frac{\text{Maximum mass}}{\text{Mass of structure}}$$

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

Restricted Response

Provide students with the following:

Which Bridge to Build?

Which of the following bridge specifications would be the most efficient and most cost-effective to build? Assume that all three bridges use the same types of materials.

- Bridge A holds 100 kg load and has a mass of 10 kg.
- Bridge B holds 100 kg load and has a mass of 50 kg.
- Bridge C holds 100 kg load and has a mass of 5 kg.

Look for:

Bridge C would be the most efficient and most cost-effective to build. It would be least expensive to construct (it requires the least amount of materials) but would be just as strong as the other bridges.

Nelson Science & Technology 7 (Section 3.15)

Sciencepower 7 (Section 14.1)

Addison Wesley Science & Technology 7 (Chapter 4, Sections 2.2-2.3)

By Design: Technology Exploration and Integration (Design Process Reference and Tools)

Design and Technology System (Design Process Reference and Tools)

Mathematics, Science, & Technology Connections (Design Process Reference and Tools)

PRESCRIBED LEARNING OUTCOMES

Students will...

7-3-11 Evaluate a structure to determine the appropriateness of its design, using the design process.

Examples: jacket, foot stool, local building...

GLO: C3, C4, C8, D4

7-0-3d Develop criteria to evaluate a prototype or consumer product. Include: function, aesthetics, environmental considerations, cost, efficiency. GLO: C3

7-0-3e Create a written plan to solve a problem. Include: materials required, three-dimensional sketches, steps to follow. GLO: C1, C3, C6

7-0-5b ↻ Test a prototype or consumer product, using predetermined criteria. GLO: C3, C5

7-0-6e ↻ Evaluate the strengths and weaknesses of a consumer product, based on predetermined criteria. GLO: C3, C4

SUGGESTIONS FOR INSTRUCTION

➢ **Evaluating the Design of a Structure**

Inform students that the school wishes to buy classroom furniture and would like input from the student body.

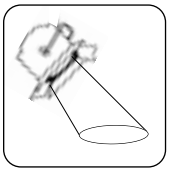
- Have groups of students choose a structure in the classroom/school (e.g., a chair, desk, or table) and evaluate it to determine the suitability of its design. Students should establish a list of criteria for determining the suitability of the design, or this should be determined in a class discussion.
- Have each group decide on a method to evaluate the structure, such as conducting surveys (e.g., to determine which type of chair people prefer) or obtaining feedback from a custodian regarding durability.
- When groups have collected and charted their data, ask them to make recommendations as to which type of furniture the school should purchase and justify their decisions according to their data.
- Have groups share their results and recommendations with the class.

Ask students to answer the following questions:

1. On what basis did you make your choice of furniture?
2. Would a school administrator decide on the same piece as you? Why or why not?
3. What factors would have the greatest influence on the administrator’s decision?

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES



Which Chair?

Provide students with the following:

Which Chair?

Your parents/guardians are going to purchase a new chair for your living room. What characteristics should you tell them to keep in mind?

Nelson Science & Technology 7 (Section 3.19)

Sciencepower 7 (Chapter 13 Review)

Addison Wesley Science & Technology 7 (Chapter 4, Sections 4.0-4.6)

PRESCRIBED LEARNING OUTCOMES

Students will...

7-3-12 Use the design process to construct a structure that will withstand the application of an external force.

Examples: a tower that will remain standing during a simulated earthquake...

GLO: C3, D3, D4

7-0-1c Identify practical problems to solve. *Examples: How can I keep my soup hot? Which type of sunscreen should I buy?…* GLO: C3

7-0-3d Develop criteria to evaluate a prototype or consumer product. Include: function, aesthetics, environmental considerations, cost, efficiency. GLO: C3

7-0-3e Create a written plan to solve a problem. Include: materials required, three-dimensional sketches, steps to follow. GLO: C1, C3, C6

7-0-4b ⊂ Construct a prototype. GLO: C3

7-0-4c ⊂ Work cooperatively with team members to carry out a plan, and troubleshoot problems as they arise. GLO: C7 (ELA Grade 7, 5.2.1)

7-0-4d ⊂ Assume various roles to achieve group goals. GLO: C7 (ELA Grade 7, 5.2.2)

7-0-4e Demonstrate work habits that ensure personal safety, the safety of others, and consideration for the environment. Include: keeping an uncluttered workspace; putting equipment away after use; handling glassware with care; wearing goggles when required; disposing of materials safely and responsibly. GLO: C1

7-0-5b ⊂ Test a prototype or consumer product, using predetermined criteria. GLO: C3, C5

7-0-5c Select and use tools to observe, measure, and construct. Include: microscopes, a variety of thermometers, graduated cylinders, glassware, balance. GLO: C2, C3, C5

7-0-6d ⊂ Identify and make improvements to a prototype, and explain the rationale for the changes. GLO: C3, C4

7-0-7d ⊂ Propose and justify a solution to the initial problem. GLO: C3

7-0-7g ⊂ Communicate methods, results, conclusions, and new knowledge in a variety of ways. *Examples: oral, written, multimedia presentations...* GLO: C6 (ELA Grade 7, 4.4.1)

SUGGESTIONS FOR INSTRUCTION

➢ Constructing a Stable Structure

Present students with the following scenario:

Prospective customers have approached your engineering firm about designing and constructing five different structures. Each structure is in a different location, and each location has special factors that will affect the design of the structure.

Read through the following list of structures with your development team and choose the structure for which you will design and create a model. The design, model, and structural stress results must be presented to the company board (class) before they can be forwarded to the customers.

Students may use the "Design Project Report" (BLM 7-N) to record their work.

Designing Structures

Structure 1: An apartment block in Vancouver where slight earthquakes have recently occurred. The developer and the future renters want the structure safe to live in during such earthquakes.

Structure 2: A ski chalet built on the side of a mountain. The area where it is to be situated has heavy snowfalls and a history of avalanches.

Structure 3: A railroad track from Thompson to Churchill. The factors to be taken into consideration are the permafrost conditions on which to build, and the weight of the grain that the railroad line owner wishes to transport.

Structure 4: Microwave towers for Churchill, an area that experiences some of the strongest winds in the province.

Structure 5: Hydro line towers for southern Manitoba. These towers need to be able to withstand the added load of ice as well as strong winds.

Suggestions for Assessment

Design Process

Provide students with the following self-assessment tool:

Design Process Self-Assessment

Name: _____

1. What I did well: _____
2. What did not work:_____
3. What I would do differently next time: _____

_____

Suggested Learning Resources

Nelson Science & Technology 7 (Unit 3: Design Challenge, Section 3.22)

Sciencepower 7 (Sections 13.1-13.2)

Addison Wesley Science & Technology 7 (Section 3.3)

By Design: Technology Exploration and Integration (Design Process Reference and Tools)

Design and Technology System (Design Process Reference and Tools)

Mathematics, Science, & Technology Connections (Design Process Reference and Tools)

Notes