Grade 5

Cluster 3: Forces and Simple Machines

Overview

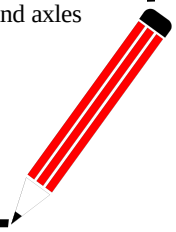
In this cluster, students increase their understanding of forces through the study of simple machines. Emphasis is placed on investigating a variety of simple machines and recognizing their usefulness for moving and lifting loads. Students explore how simple machines are used in daily life, and they identify advantages and disadvantages of using simple machines for a given task. Students apply their knowledge of simple machines by designing, constructing, and evaluating a prototype.

PRESCRIBED LEARNING OUTCOMES	SUGGESTIONS FOR INSTRUCTION
Students will...	
5-3-01 Use appropriate vocabulary related to their investigations of forces and simple machines. Include: applied force, balanced and unbalanced forces, fulcrum, load, friction, terms related to types of simple machines. GLO: C6, D4	

Teacher Notes

Prior Knowledge

Students have investigated force, the inclined plane, and wheel and axles in Grade 2, Cluster 3: Position and Motion. Students have also investigated force (magnetism, gravity, and static electricity) in Grade 3, Cluster 3: Forces That Attract or Repel. In both grades, force has been defined as a push or a pull.



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

➢ **Sort and Predict**

Have students use the Sort and Predict strategy (Brownlie and Close, 1992) to learn new terms (early in the cluster) or to review terms (later in the cluster). Provide a list of 15 to 20 key terms from the cluster and have student groups develop four categories for the terms, each with its own criteria. In groups, have students place the terms so that each category has at least three terms. (This sorting can be done physically using cut-out terms.) Each group then selects a spokesperson to share their categories with the class.

(For a BLM of a Sort and Predict Frame, see *SYSTH*, Attachment 10.13, or *Success*, p. 6.100.)

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

Teacher Notes

Set up a Simple Machines centre featuring devices that consist of simple machines. Have students add to the centre throughout the study of the cluster. At the centre, have students identify what each device is used for, then take each device apart and observe and describe the simple machines that it contains.

Prescribed Learning Outcomes

Students will...

5-3-02 Describe, using diagrams, the forces acting on an object and the effects of increasing or decreasing them.

Include: force arrows representing direction and relative strength of forces acting in the same plane, balanced and unbalanced forces.

GLO: C6, D4

5-0-4c Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise. GLO: C7 (ELA Grade 5, 5.2.2)

5-0-4e Use tools and materials in a manner that ensures personal safety and the safety of others. Include: keeping an uncluttered workspace; putting equipment away after its use; handling glassware with care. GLO: C1

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

5-0-5f Record and organize observations in a variety of ways. *Examples: point-form notes, sentences, labelled diagrams, charts, ordered lists of data, frequency diagrams, spread sheets…* GLO: C2, C6 (ELA Grade 5, 3.3.1; Math: SP-III.2.5)

5-0-6c Identify and suggest explanations for patterns and discrepancies in data. GLO: A1, A2, C2, C5

5-0-7g Communicate methods, results, conclusions, and new knowledge in a variety of ways. *Examples: oral, written, multimedia presentations...* GLO: C6 (ELA Grade 5, 4.4.1; TFS: 3.2.2, 3.2.3)

(continued)

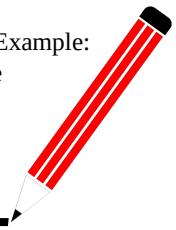
Suggestions for Instruction

Teacher Notes

Background Information

Newton's laws of motion state:

1. Objects in motion tend to stay in motion and objects at rest tend to stay at rest unless they are acted upon by some outside force. (A moving ball eventually stops due to the friction of the surface it is moving upon. A ball sitting on the floor will not move unless it is pushed or pulled in some way.)
2. The greater the force acting on an object, the more it changes in speed or direction; the heavier an object is, the less it changes in speed or direction. (Greater force is required to throw a ball that travels quickly than to throw a ball that travels slowly. It is easier to throw a light rock a long distance than it is to throw a heavier one a long distance.)
3. For every action there is an equal and opposite reaction. (Example: When a filled balloon is released the air escaping from the balloon propels the balloon forward.)



➢ Looking at Forces

Ask students to define a *force*. Have them demonstrate what is meant by a *push* or a *pull*.

➢ Balanced and Unbalanced Forces

Arrange teams that are fairly equal and have students participate in a tug-of-war. What happens when students try pulling on the rope?

Form unequal teams and have students tug on the rope. Observe what happens. Ask students to state reasons for what they observed using the term *forces*. Ask them how this might be represented on paper. Record their suggestions. Demonstrate how to use the arrows to represent the forces, introducing the terms *balanced forces* and *unbalanced forces.*

(continued)

Suggestions for Assessment

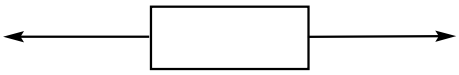
Suggested Learning Resources

Teacher Notes

Background Information

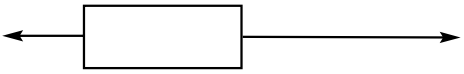
The direction and strength of a force is represented by arrows called *vectors*. A longer arrow represents a stronger force. The point of the arrow shows the direction in which the force is being applied. This can be illustrated by imagining a rope being attached to the location where the force is applied, and pulling in the direction the force is applied. Pairs of forces are usually included in force diagrams and it is possible to predict the movement of the object by comparing the relative size of the forces.

Balanced forces:



The object will remain in place because the forces are equal.

Unbalanced forces:



The object will move to the right because the force pulling to the right is greater than that pulling to the left.

PRESCRIBED LEARNING OUTCOMES	SUGGESTIONS FOR INSTRUCTION
Students will...	
5-3-02 *(continued)*	*(continued)* ➢ **Forces Investigation** Using a gymnasium or a large room, divide the class into small groups. Give each group a soccer ball or a "sponge-type" ball and the following directions: You have six problems to solve. Work together and do one problem at a time. Record your solutions both in words and diagrams, using force arrows to show what is happening. 1. How can you set the ball in motion? 2. How can you change the speed of a moving ball so that it continues to move faster? 3. How can you slow down the speed of a moving ball without stopping it? 4. How can you slow down the speed of a moving ball without touching it? 5. How can you stop a moving ball? 6. How can you change the direction of a moving ball? After all groups are finished, have each group share their solutions. Use the following questions for discussion: • Based on your observations, what evidence shows that an applied force can cause an object to change speed or direction? • Can you think of instances when an applied force might not cause change in an object?

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

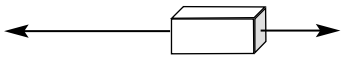
Extended Response

Provide students with the following:

Balanced and Unbalanced Forces

Explain what will happen to the object in each of the following situations.

1.



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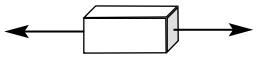

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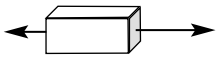

4. Explain, using diagrams, balanced and unbalanced forces.

Look for:

1. It will move to the left because the force pulling to the left is greater than the force pulling to the right.
2. It will remain in place because the forces are equal and balanced.
3. It will move to the right because the force pulling to the right is greater than the force pulling to the left.

PRESCRIBED LEARNING OUTCOMES

Students will...

5-3-03 Investigate a variety of levers used to accomplish particular tasks in order to compare them qualitatively with respect to fulcrum position, applied force, and load.

Include: first-class, second-class, and third-class levers.

GLO: C2, D4, E1

5-0-4c Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise. GLO: C7 (ELA Grade 5, 5.2.2)

5-0-4e Use tools and materials in a manner that ensures personal safety and the safety of others. Include: keeping an uncluttered workspace; putting equipment away after its use; handling glassware with care. GLO: C1

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

5-0-5c Select and use tools and instruments to observe, measure, and construct. Include: balance, thermometer, spring scale, weather instruments. GLO: C2, C3, C5

5-0-7f Use prior knowledge and experiences selectively to make sense of new information in a variety of contexts. GLO: A2, C4 (ELA Grade 5, 1.2.1)

5-0-7h Identify, with guidance, potential applications of investigation results. GLO: C4

5-0-9c Demonstrate confidence in their ability to carry out investigations. GLO: C5

(continued)

SUGGESTIONS FOR INSTRUCTION

➢ Exploring Levers: The Teeter-Totter

Introduce the concept of a *lever* to students. Have the class visit a local playground to examine the workings of a teeter-totter. Place two students of approximately the same size on opposite ends of a teeter-totter and have them balance so the teeter-totter is parallel to the ground. Replace one student with an adult and let the teeter-totter come to rest. Challenge students to figure out how to balance the teeter-totter without adding more force. (Moving the adult closer to the fulcrum [shortening the load arm] will achieve balance.)

➢ Investigating Levers

Have students test whether the use of a lever (class one) can make it easier to move an object. Divide students into small groups and provide each group with a metre stick or light board (lever), a spring scale, a wooden block (fulcrum), an empty tin can with a handle attached, small objects or other cans to act as weights, adhesive tape, and string. (If a spring scale is not available, use an identical can with a set of weights, or small objects used as weights, to balance the lever.) The emphasis is on the relative force needed to balance the load, not on precise measurements.

Part 1: Fulcrum in the Middle

1. Place the weights in the can and suspend it from the spring scale.
2. Record the weight of the can when it is lifted from the ground.
3. Set the fulcrum (wooden block) on the corner of a desk or on a ledge to allow free movement of the lever (metre stick or board) and balance the lever on the fulcrum at the 50 cm mark (or midway point of the lever). A piece of tape can be placed loosely over the lever and fulcrum to keep the lever from slipping.
4. Remove the can with weights from the spring scale and place it on one end of the lever (holes can be made on both ends of the lever to facilitate this).
5. Attach the spring scale to the other end of the lever. Pull down on the spring scale and achieve balance by raising the can to the same level as the wooden block.

(continued)

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

Teacher Notes

Background Information

- A *lever* is a bar or rod that is hinged or pivoted to turn around a fixed point called a *fulcrum*. It is used to transfer force and motion. A force at one end of the lever causes a load on the other end to move in the opposite direction.
- Levers are categorized into three classes, depending on the relative positions of the weight and the force applied. (For a description of class one, class two, and class three levers, see "Types of Levers," BLM 5-B.)

PRESCRIBED LEARNING OUTCOMES	SUGGESTIONS FOR INSTRUCTION
Students will...	
5-3-03 *(continued)*	*(continued)*

6. Record the force required. Compare it with amount of force required to lift the can with and without the lever.
7. Repeat this same test with different amounts of weight in the can.
8. Have students summarize their findings in their science notebooks. (The amount of force needed to balance the lever is equal when the fulcrum is in the middle of the lever.) Identify a practical example to illustrate the findings. (Two people of equal size are needed to balance a teeter-totter when they are the same distance from the fulcrum.)

Part 2: Moveable Fulcrum

1. Predict what will happen when the fulcrum is placed closer to the load, and when the fulcrum is placed closer to the applied force.
2. Place the fulcrum at the 75 cm mark of the lever (or halfway between where it was placed originally and where the load is applied).
3. Record the applied force needed to balance the original load used in Part 1. Observe the distance the applied force end of the lever needs to move to achieve balance, compared to when the fulcrum was located in the centre of the lever in Part 1. (The force required to achieve balance is less than when the fulcrum is in the centre, but the force must be applied over a longer distance to achieve balance.)
4. Move the fulcrum to the 25 cm mark (or halfway between where it was placed originally in Part 1 and where the load is applied).
5. Record the applied force needed to balance the original load and observe the distance the applied force end of the lever needs to move in order to achieve balance, compared to when the fulcrum was located in the centre of the lever in Part 1. (The force required to achieve balance is more now than when the fulcrum was in the centre, but the force is applied over a shorter distance.)
6. Predict and then test the force needed to balance the load and the distance the applied force end of the lever needs to move when the fulcrum is moved to the 85 cm and 15 cm positions.
7. Have students summarize their findings in their science notebooks and include a labelled diagram.

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SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

Teacher Notes

Moveable Fulcrum

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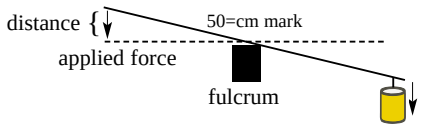
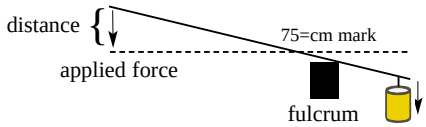
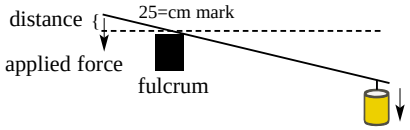


b.



Less force is required to balance the load, but it is applied over a longer distance.

c.



Greater force is required to balance the load, but it is applied over a shorter distance.

PRESCRIBED LEARNING OUTCOMES	SUGGESTIONS FOR INSTRUCTION
Students will...	
5-3-03 *(continued)*	*(continued)*

8. Have students use their findings to explain where they would place the fulcrum on a lever designed to move a large boulder on a driveway, and explain why they chose the particular placement.

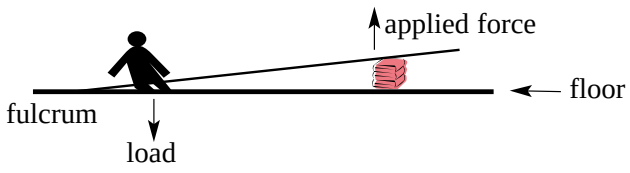
➢ **Class Two Levers**

Introduce the concept of different classes of levers to students. Explain that the lever students used in the previous learning activities is called a *class one lever* because the fulcrum is placed between the applied force and the load. In a *class two lever* the load is between the applied force and the fulcrum. In this type of lever the applied force always travels a greater distance than the load and is less than the load force.

To demonstrate how a class two lever works, put one end of a sturdy board on a small stack of books or another object that will keep it off the floor. Have a student sit near the other end (approximately one quarter of the distance along the board). The end of the board that stays on the ground is the fulcrum. Lift the end of the lever that is sitting on the books to raise the student a short distance. Have the student move closer to the applied force. Does this make it easier or more difficult to move the student? (It makes it more difficult.) Have students take turns lifting the lever.

Repeat the learning activity with a longer board, and the same student. Students should observe that a longer board arm makes the student easier to lift, but that the applied force end of the longer board has to travel farther to make the student move than was required with the shorter board. Ask students to summarize their findings in their science notebooks, and include labelled diagrams.

Class Two Lever



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SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

Journal Reflection

Provide students with the following:

Class Two Lever

In your science notebook, explain why a bottle opener is a class two lever.

Look for:

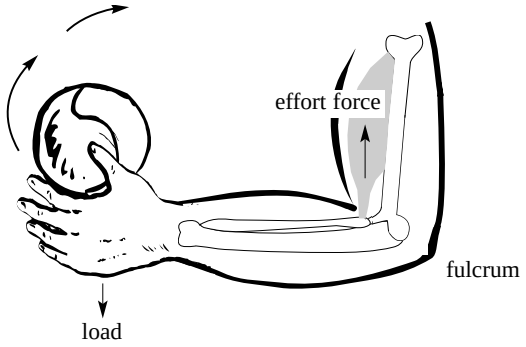
The fulcrum is the end that touches the top of the bottle cap. The force is applied to the other end. The hook that is between the fulcrum and the end where the force is applied pulls up the bottle cap.

PRESCRIBED LEARNING OUTCOMES	SUGGESTIONS FOR INSTRUCTION
Students will...	
5-3-03 *(continued)*	*(continued)*

➢ **Class Three Levers**

Introduce the concept of a *class three lever* to students. In a class three lever the applied force is placed between the load and the fulcrum, and the applied force always travels a shorter distance than the load and must be greater than the load force. Have students work in small groups to determine how their arm, curling a weight (see diagram), is a lever. Ask them to demonstrate this action and draw a diagram. Have students label the position of the fulcrum, the applied force, and the load.

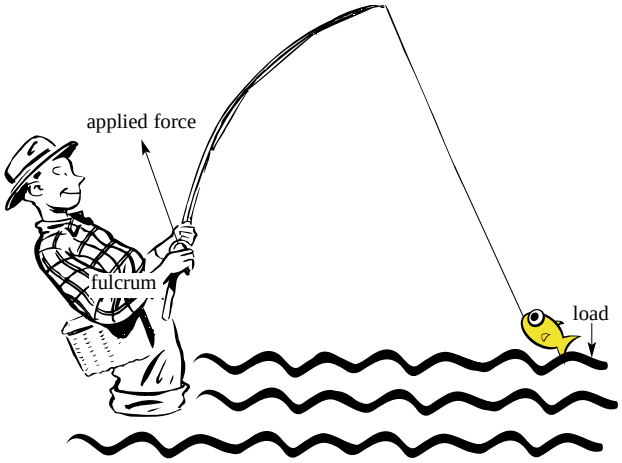
Class Three Lever



Following a class discussion of students' diagrams, allow students to select one of the following tools and use a labelled diagram to illustrate how it is a class three lever.

- fishing rod
- baseball bat
- hammer

Example (fishing rod):



SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

Teacher Notes

In investigating a class three lever, remind students to consider not only the device but also the role the human body plays in the lever. For example: a fishing rod is a lever that is actually an extension of the human arm. The wrist is the fulcrum and the arm is the force arm. The fulcrum is at one end of the lever, with the effort applied partway along the lever and the load at the opposite end of the fulcrum.

PRESCRIBED LEARNING OUTCOMES	SUGGESTIONS FOR INSTRUCTION
Students will...	
5-3-03 *(continued)*	*(continued)* ➢ **Putting It All Together** Have students use the Three-Point Approach (Simons, 1991) to • write definitions of the terms *class one lever*, *class two lever*, and *class three lever* in their own words • draw a labelled diagram representing each term • give an example of an everyday device representing each term **Note:** The terms *lever, fulcrum*, *applied force*, and *load force* should be used with each definition and diagram. (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

Extended Response

Provide students with the following:

Levers

A **B** **C**

1. Identify the class of lever shown in each picture.
2. Explain how you know.

Look for:

A = class two because it has the fulcrum at one end and the load acts downward between the applied force and the fulcrum.

B = class one because it has the fulcrum in between the load and the applied force.

C = class three because it has the fulcrum at one end and the load at the other end with the applied force between them.

Scoring Rubric	
Score	**Criteria**
3	Correctly identifies the lever class for the three pictures. Provides a clear explanation for each picture.
2	Correctly identifies the lever class for the three pictures. Explanation is unclear or has minor errors or omissions.
	Correctly identifies the lever class for two pictures. Provides a clear explanation for both.
1	Correctly identifies the lever class for the three pictures. Explanation is missing.
	Correctly identifies the lever class for two pictures. Explanation is unclear or has minor errors or omissions.
	Correctly identifies the lever class for one picture. Explanation is clear and correct.

PRESCRIBED LEARNING OUTCOMES

Students will...

5-3-04 Identify objects in the school and at home that use wheels and axles, and describe the forces involved.

Examples: doorknob, manual pencil sharpener, hinge, bicycle...

GLO: B1, D4, E1

5-0-5c Select and use tools and instruments to observe, measure, and construct. Include: balance, thermometer, spring scale, weather instruments. GLO: C2, C3, C5

5-0-5d Evaluate the appropriateness of units and measuring tools in practical contexts. GLO: C2, C5 (Math: SS-I.1.5)

5-0-5e Estimate and measure mass/weight, length, volume, and temperature using SI and other standard units. GLO: C2, C5 (Math: SS-IV.1.5, SS-III.1.5, SS-I.1.5, SS-VIII.4.3)

5-0-6c Identify and suggest explanations for patterns and discrepancies in data. GLO: A1, A2, C2, C5

5-0-7g Communicate methods, results, conclusions, and new knowledge in a variety of ways. *Examples: oral, written, multimedia presentations...* GLO: C6 (ELA Grade 5, 4.4.1; TFS: 3.2.2, 3.2.3)

SUGGESTIONS FOR INSTRUCTION

➢ Wheel and Axle Hunt

Have students use the Think-Pair-Share strategy (McTighe and Lyman, 1992) to think of objects in the home and the school that use a wheel and axle. Make a class list of the suggestions.

➢ Wheel and Axle Investigation

Provide pairs of students with a compass for drawing circles. If compasses are not available, have students use a large plastic lid as a tracer, a manila tag at least 10 cm square, a pencil, scissors, and a metre stick.

Have students:

1. Use the compass to make a circle on the paper and then cut it out.
2. Insert the pencil through the centre of the circle to make a wheel and axle.
3. Predict how many times the pencil will rotate when the wheel rotates once.
4. Roll the wheel and axle along a tabletop and observe how many times the pencil rotates when the wheel rotates once.
5. Measure the distance the wheel travels in one complete rotation. (Put a small mark on the wheel so you can see when it has completed one rotation.)
6. Remove the pencil from the wheel, place the pencil on the table, and measure the distance the pencil travels in one complete rotation.
7. Predict how far the pencil will travel if the wheel rotates 10 times.
8. Reinsert the pencil (axle) through the centre of the wheel and measure how far the pencil travels in 10 rotations.
9. Draw a diagram of the wheel and axle used in this investigation, including force arrows to show the forces involved.

➢ Identifying Forces

Have students refer to the class list of wheels and axles found at school and at home (see the Wheel and Axle Hunt learning activity in conjunction with learning outcome 5-3-04). Have pairs of students select one of the objects listed and use diagrams to explain the forces involved.

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

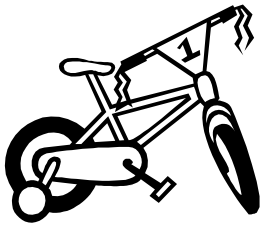
Extended Response

Provide students with the following:

Wheels and Axles

Both the following objects use wheels and axles. Explain how they work. Be sure to describe the forces involved.

1.



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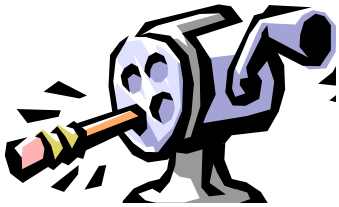
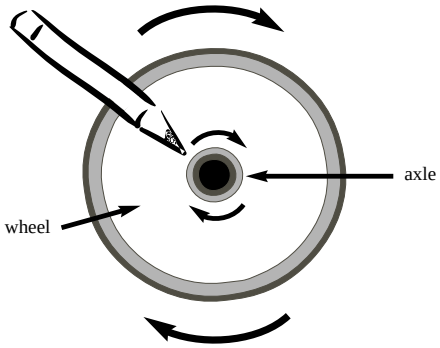


Teacher Notes

Background Information

The wheel and axle comprise a simple machine made up of a small wheel (axle) attached to the centre of a large wheel. The axle is usually a rod and it always turns as the large wheel turns.

Example of a pencil and wheel drawing:



PRESCRIBED LEARNING OUTCOMES

Students will...

5-3-05 Recognize that a gear is a wheel and axle used to turn another wheel and axle.

GLO: D4, E2

5-0-4c Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise. GLO: C7 (ELA Grade 5, 5.2.2)

5-0-4e Use tools and materials in a manner that ensures personal safety and the safety of others. Include: keeping an uncluttered workspace; putting equipment away after its use; handling glassware with care. GLO: C1

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

5-0-7f Use prior knowledge and experiences selectively to make sense of new information in a variety of contexts. GLO: A2, C4 (ELA Grade 5, 1.2.1)

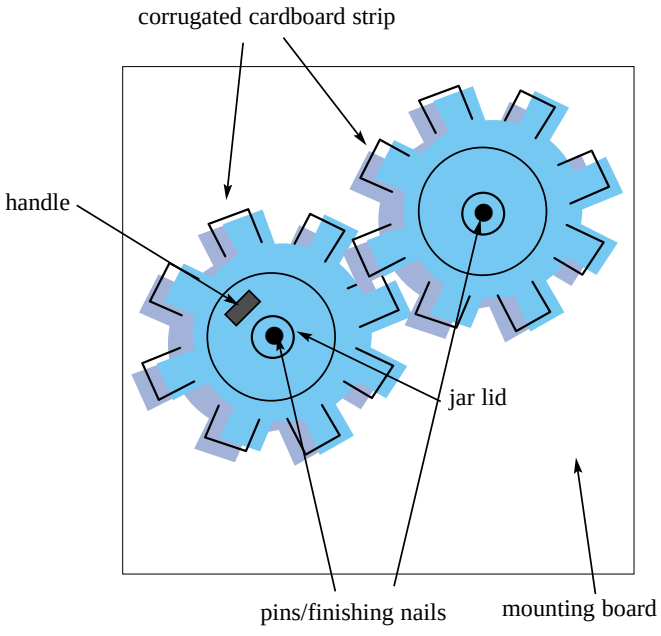
SUGGESTIONS FOR INSTRUCTION

➢ Investigating Gears

Have students bring to class a collection of differently sized jar lids. Cut corrugated cardboard into strips about 1 cm wide. Provide pairs of students with three jar lids, a strip of cardboard, pieces of mounting board (plywood/particleboard), styrofoam, pins or small finishing nails, a small piece of wood or game marker to use as a handle, and glue.

Have students follow these directions to make a gear system:

1. Peel away the cardboard on one side so that the corrugation is exposed. Glue the corrugated cardboard onto the outside rim of a jar lid so that the corrugation faces out.
2. Make a small hole in the centre of the lid (with teacher assistance). Pin the gear to the mounting board so that it spins freely.
3. Select a lid of a different size and attach it to the board so that the teeth of both gears mesh.
4. Glue a small piece of wood or a game marker to one of the lids. Use it as a handle to turn the gear. Observe what happens.
5. See whether you can attach another lid and have it turn with the other two.
6. Record your findings in your science notebook.



SUGGESTIONS FOR ASSESSMENT	SUGGESTED LEARNING RESOURCES
Refer to the assessment strategy suggested for learning outcome 5-3-06.	

PRESCRIBED LEARNING OUTCOMES
Students will...
5-3-06 Identify common devices and systems that incorporate pulleys and/or gears. GLO: A5, B1, D4, E1
5-0-5a Make observations that are relevant to a specific question. GLO: A1, A2, C2

SUGGESTIONS FOR INSTRUCTION

➢ **Gear and Pulley Hunt**

Have students look at home and at school for objects that make use of gears and/or pulleys. Have them share their findings with the class.

Teacher Notes

This learning activity could follow learning outcome 5-3-08. It could also be done at several stages in the cluster, where students look for gears at this time and pulleys at another time.

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

Extended Response

(Learning outcomes 5-3-05 and 5-3-06)

Provide students with the following:

Pulleys and Gears

In your science notebook, list common devices and systems that use pulleys or gears. Name a device that uses both pulleys and gears.

PRESCRIBED LEARNING OUTCOMES

Students will...

5-3-07 Explore to determine how the direction and amount of the applied force and the speed of rotation vary within a two-gear system.

GLO: C2, D4, E2

5-0-4e Use tools and materials in a manner that ensures personal safety and the safety of others. Include: keeping an uncluttered workspace; putting equipment away after its use; handling glassware with care. GLO: C1

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

5-0-5f Record and organize observations in a variety of ways. *Examples: point-form notes, sentences, labelled diagrams, charts, ordered lists of data, frequency diagrams, spread sheets…* GLO: C2, C6 (ELA Grade 5, 3.3.1; Math: SP-III.2.5)

5-0-7a Draw, with guidance, a conclusion that explains investigation results. Include: explaining patterns in data; supporting or rejecting a prediction/hypothesis. GLO: A1, A2, C2 (ELA Grade 5, 3.3.4)

SUGGESTIONS FOR INSTRUCTION

➢ Investigating Direction and Speed of a Two-Gear System

Have students use the gears and board from the Investigating Gears learning activity in conjunction with learning outcome 5-3-05. Ensure students have small, medium, and large lid gears.

Have students investigate the direction and space of a two-gear system, following these steps:

1. Attach the largest gear to the board.
2. Attach the smallest gear so that it interlocks with the largest one.
3. Move the largest gear one rotation clockwise. In what direction does the small gear move? (Counterclockwise.) How many rotations does the small gear make?
4. Turn the small gear one rotation clockwise. In what direction does the large gear turn? (Counterclockwise.) How many rotations does the large gear make?
5. Turn the small gear four full rotations. How many rotations does the small gear make?
6. Remove the small gear and attach the middle-sized gear. Repeat steps 3 through 5.
7. Record your findings about the relationships between gears in your science notebook.

➢ Investigating Force

For this investigation students need three gears: one with 12 teeth, one with six teeth, and one with four teeth. These can be cut from cardboard (see “Gear Template,” BLM 5-C). Have students attach the gears to a board or a styrofoam tray with bendable fasteners.

Ask students to investigate the gears and answer the following questions:

1. How many times do you have to turn the small gear to have the large gear make one complete turn? (Three.)
2. How far do you think the large gear will turn if you turn the small gear once? (One third of the way.)
3. Repeat the investigation using the medium-sized gear with the large gear, and then the medium-sized gear with the small gear. Ask students to draw a diagram of each two-gear system, making sure to include appropriate force arrows.
4. Which gear requires the least force to move?
5. Which gear must travel the greatest distance for one rotation?
6. Write a paragraph in your science notebook summarizing what you have learned about gears in this learning activity.

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

Extended Response

Provide students with the following:

Two-Gear System

In your science notebook, explain how a two-gear system works. In your explanation, include information about direction, applied force, and speed of rotation.

Prescribed Learning Outcomes

Students will...

5-3-08 Compare, quantitatively, the force required to lift a load using a pulley system versus a single fixed pulley, and recognize the relationship between the force required and the distance over which the force is applied.

Include: a system of pulleys reduces the force required while increasing the distance over which the force is applied; a single fixed pulley requires a greater force but applies it over a shorter distance.

GLO: C2, D4, E2

5-0-1a Formulate, with guidance, specific questions that lead to investigations. Include: rephrase questions to a testable form, focus research questions. GLO: A1, C2 (ELA Grade 5, 3.1.1; Math: SP-I.1.5)

5-0-3a Formulate, with guidance, a prediction/hypothesis that identifies a cause and effect relationship. GLO: A2, C2 (Math: SP-I.1.5)

5-0-3b Identify variables that might have an impact on their experiments and, with guidance, variables to hold constant to ensure a fair test. GLO: A2, C2

5-0-3c Create a written plan to answer a specific question. Include: apparatus, materials, safety considerations, steps to follow. GLO: C2 (ELA Grade 5, 3.1.4)

5-0-4a Carry out, with guidance, procedures that comprise a fair test. Include: controlling variables, repeating measurements to increase accuracy and reliability. GLO: C2

5-0-4e Use tools and materials in a manner that ensures personal safety and the safety of others. Include: keeping an uncluttered workspace; putting equipment away after its use; handling glassware with care. GLO: C1

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

5-0-5c Select and use tools and instruments to observe, measure, and construct. Include: balance, thermometer, spring scale, weather instruments. GLO: C2, C3, C5

5-0-5d Evaluate the appropriateness of units and measuring tools in practical contexts. GLO: C2, C5 (Math: SS-I.1.5)

(continued)

Suggestions for Instruction

Teacher Notes

Background Information

A *fixed pulley system* is one in which the pulley is attached to a structure and does not move. A pulley system in which one pulley supports the load and is not fixed to a structure while a second pulley is fixed is called a *moveable pulley system.*

➢ Single Fixed Pulley

Ask students to imagine how difficult it would be for people to raise the flag every day if they did not have a simple machine to help them. Provide students with a single pulley, a metre stick, string, several textbooks, and a spring scale.

Have students make a model of the single fixed pulley system, following these directions:

1. Tie the string around the books in the way that you would a parcel, leaving one end of the string loose (1 metre).
2. Tie the pulley to the middle of the metre stick and support the stick between two chairs.
3. Place the books on the floor below the pulley and thread the loose end of the string through the pulley.
4. Attach a spring scale to the string and pull down, lifting the books off the floor.
5. Detach the books from the pulley and, using the spring scale, lift the books to the same height (as in step 4) without using the pulley.
6. Record your results.
7. Explain your findings in your science notebook, using the terms *force* and *direction*.

(The spring scale reading should be the same in both cases because the single pulley changes the direction of the force but does not change the amount of force required. Single pulleys are often used to lift a load vertically, as it is easier to pull down to lift the load than to pull up to lift it.)

(continued)

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

Prescribed Learning Outcomes

Students will...

5-3-08 *(continued)*

5-0-5e Estimate and measure mass/weight, length, volume, and temperature using SI and other standard units. GLO: C2, C5 (Math: SS-IV.1.5, SS-III.1.5, SS-I.1.5, SS-VIII.4.3)

5-0-5f Record and organize observations in a variety of ways. *Examples: point-form notes, sentences, labelled diagrams, charts, ordered lists of data, frequency diagrams, spread sheets…* GLO: C2, C6 (ELA Grade 5, 3.3.1; Math: SP-III.2.5)

5-0-6a Construct graphs to display data, and interpret and evaluate these and other graphs. *Examples: bar graphs, frequency tallies, line plots, broken line graphs…* GLO: C2, C6 (ELA Grade 5, 3.3.1; Math: SP-II.1.5, SP-III.2.5, SP-IV.1.5; TFS: 4.2.2–4.2.6)

5-0-6c Identify and suggest explanations for patterns and discrepancies in data. GLO: A1, A2, C2, C5

5-0-6f Evaluate the methods used to answer a question or solve a problem. GLO: C2, C3 (ELA Grade 5, 3.3.4)

5-0-7a Draw, with guidance, a conclusion that explains investigation results. Include: explaining patterns in data; supporting or rejecting a prediction/hypothesis. GLO: A1, A2, C2 (ELA Grade 5, 3.3.4)

5-0-7b Base conclusions on evidence rather than preconceived ideas or hunches. GLO: C2, C4

5-0-7c Identify, with guidance, a new prediction/hypothesis, based on investigation results. GLO: A1, C2 (ELA Grade 5, 3.3.4)

5-0-7h Identify, with guidance, potential applications of investigation results. GLO: C4

(continued)

Suggestions for Instruction

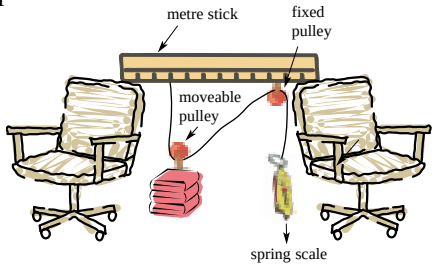
(continued)

➢ Moveable Pulley Systems

Ask students whether they think a pulley system with one pulley that moves can make it easier to lift a load than a single pulley that is fixed (see Single Fixed Pulley learning activity, learning outcome 5-3-08). Provide small groups of students with a metre stick, string, two pulleys, several books, and a spring scale.

Have students compare pulley systems, following these directions:

1. Attach one end of the string to a metre stick supported by two chairs.
2. Thread the string through a moveable pulley that is attached to the same books that were used in the Single Fixed Pulley learning activity.
3. Thread the string through the fixed pulley attached to the metre stick.



4. Attach the spring scale to the other end of the string.
5. Pull down on the spring scale to lift the books (adjust the length of the string as needed). Record the force required.
6. Answer the following questions in your science notebook:
   a. How does the force needed to lift the books with this pulley system compare to the force required in the single fixed pulley? (It is less—approximately half.)
   b. What did you notice about how far the string needed to be pulled with the moveable pulley system? (It was pulled a greater distance.)
   c. Based on your investigations, write a summary statement describing your understanding of the relationship between force and distance operating in pulley systems. If you reduce the force required to lift a load, you increase the distance over which the force must be applied.)

(continued)

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

Extended Response

Provide students with the following:

Advantages and Disadvantages

In your science notebook, explain the advantages and disadvantages of using a moveable pulley system and a single fixed pulley.

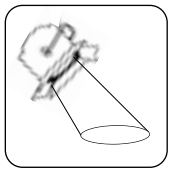
Look for:

- a moveable pulley system reduces the force required, while increasing the distance over which the force is applied
- a single fixed pulley requires greater force than a moveable pulley system but applies it over a shorter distance

PRESCRIBED LEARNING OUTCOMES	SUGGESTIONS FOR INSTRUCTION
Students will...	
5-3-08 *(continued)*	*(continued)* ➢ **Pulley Investigations** Have students investigate to determine the effect of using more than one pulley to lift a load. Ask students to make a prediction identifying cause and effect (e.g., increasing the number of pulleys will make it easier to lift a specified load). Have students • identify the variables • create a written plan for the investigation • carry out the experiment • collect data and present them in graph form, including force arrows in the diagrams • identify potential applications of their findings Students may use the "Experiment Report" (BLM 5-K) to record their work. Refer to page 12 of this document for a description of the scientific inquiry process.
5-3-09 Identify and make modifications to their own pulley and/or gear systems to improve how they move loads. Include: reducing friction. GLO: C3, D4, E2	➢ **Improving Your Pulley or Gear System** Have students provide suggestions on how to improve the pulley system constructed in conjunction with learning outcome 5-3-08, or the gear system constructed in conjunction with learning outcome 5-3-07. Ensure that students identify ways to reduce friction in their systems.
5-0-6d Identify and make improvements to a prototype, and explain the rationale for the changes. GLO: C3, C4	

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES



The Hole

Provide students with the following:

The Hole

Imagine that a large man has fallen into a deep hole with slippery sides. The man tries to climb out but cannot. At the top of the hole there is a long rope and a pair of pulleys that the man was taking to work. A small child is travelling with the man. The man can shout directions, but he cannot expect the child to run for help or to pull him up.

What should the man tell the child to do in order to help him out of the hole? Write the directions and then draw a diagram of what you suggest.

Look for:

The student

- describes how to assemble a two-pulley system
- gives clear directions
- includes a labelled diagram

PRESCRIBED LEARNING OUTCOMES

Students will...

5-3-10 Identify and describe types of simple machines.

Include: levers, wheel and axle, pulley, gear, inclined plane, screw, wedge.

GLO: D4

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

5-0-5f Record and organize observations in a variety of ways. *Examples: point-form notes, sentences, labelled diagrams, charts, ordered lists of data, frequency diagrams, spread sheets…* GLO: C2, C6 (ELA Grade 5, 3.3.1; Math: SP-III.2.5)

5-0-7g Communicate methods, results, conclusions, and new knowledge in a variety of ways. *Examples: oral, written, multimedia presentations...* GLO: C6 (ELA Grade 5, 4.4.1; TFS: 3.2.2, 3.2.3)

5-0-7h Identify, with guidance, potential applications of investigation results. GLO: C4

SUGGESTIONS FOR INSTRUCTION

➢ **Types of Simple Machines**

Use explicit instruction to summarize the types of simple machines students have studied in Grade 5 and in previous grades (levers, wheel and axle, pulley, gear, inclined plane) and introduce two new types, the *screw* and the *wedge* (variations of the inclined plane).

➢ **Screws in the Environment**

Have students hunt for evidence of the use of the screw in objects in the environment. Have them note its location, describe its function, and draw a diagram of how it works.

I found a screw _____.

It is used to _____

_____.

Diagram:

➢ **Identifying Simple Machines**

Have students write down the names of the six different simple machines. (See "include," learning outcome 5-3-10. The gear is considered to be a type of wheel and axle.) Have them work with a partner to think of objects that use each simple machine.

Some objects may fit into several categories. Students should be able to justify the placement of the object in a given category. Have them share their lists with the class.

➢ **Simple Machine Posters**

Have students select one simple machine and design a poster explaining what it is, what it does, and where it can be found.

➢ **Simple Machine Rap**

Divide students into small groups and have each group select one simple machine and create a verse for a simple machine rap, poem, or song. Suggest that students present their creation to another class.

➢ **Machine Families**

All simple machines are modifications of either inclined planes or levers. Have students sort the simple machines into these two categories and give reasons for their placement.

Suggestions for Assessment

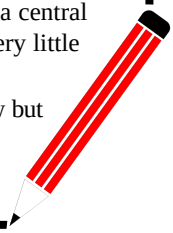
Refer to the assessment strategy suggested for learning outcome 5-3-11.

Teacher Notes

Background Information

- A *wedge* is a simple machine that is used to push things apart. It acts as a moving inclined plane. Most cutting tools, such as knives, are wedges.
- An *inclined plane* is a sloping surface, such as a ramp. It makes moving or lifting an object easier.
- A *screw* is a simple machine that is adapted from an inclined plane. If you follow the thread from the tip of the screw, you will see an inclined plane constantly curving upward around a central shaft. A screw is used to apply tremendous force with very little effort.

Note: Students have not been introduced to the wedge or screw but they have had experience with the inclined plane in Grade 2, Cluster 3: Position and Motion.

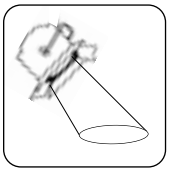


Suggested Learning Resources

PRESCRIBED LEARNING OUTCOMES	SUGGESTIONS FOR INSTRUCTION
Students will...	
5-3-11 Describe the advantage of using simple machines to move or lift a given load. Include: to decrease the force required; to increase the resulting force; to change the direction of the applied force. GLO: D4	➢ **Why Use Simple Machines?** As a class, summarize the main advantages of using simple machines. Working in small groups, have students use the advantages as headings and list examples of types of simple machines with those advantages under each heading. Example: **decreases the applied force required:** • inclined plane • single moveable pulley • class two lever **increases the resulting force:** • wedge • screw **changes the direction of the applied force:** • wheel and axle • single fixed pulley • gear Have students complete the following summary statement in their notebooks: Simple machines are examples of technologies that help humans make work easier. (They do this by a) decreasing the applied force required, b) increasing the resulting force, c) changing the direction of the applied force.)
5-0-7g Communicate methods, results, conclusions, and new knowledge in a variety of ways. *Examples: oral, written, multimedia presentations...* GLO: C6 (ELA Grade 5, 4.4.1; TFS: 3.2.2, 3.2.3) **5-0-8c** Recognize that technology is a way of solving problems in response to human needs. GLO: A3, B2	
5-3-12 Investigate to identify advantages and disadvantages of using different simple machines to accomplish the same task. *Examples: using a pulley, inclined plane, or lever to move a piano to the second floor...* GLO: B1, C2, C4, D4	➢ **What Works Best?** Present students with the following scenario: You have been hired to move the school piano from the first floor to the second floor. You must use one of the six simple machines. Identify the simple machines that might be used to complete the task. Evaluate each machine by identifying the advantages and disadvantages of using it to move the piano. Finally, prepare a written plan (including diagrams) to present to the principal on the best way to accomplish the task.
5-0-7h Identify, with guidance, potential applications of investigation results. GLO: C4 **5-0-8c** Recognize that technology is a way of solving problems in response to human needs. GLO: A3, B2	

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES



The Easy Life

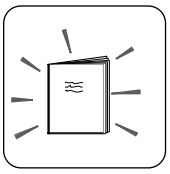
(Learning outcomes 5-3-10 and 5-3-11)

Provide students with the following:

The Easy Life

Think about a typical day in your life.

What simple machines do you use over the course of the day? How do these simple machines make your life easier? Be specific.



"What Works Best?" Written Plan

Look for indications of the following in student work:

Checklist

The plan

- ❑ identifies appropriate simple machines
- ❑ states advantages for each machine
- ❑ states disadvantages for each machine
- ❑ is thorough and clearly written
- ❑ is appropriate and workable

PRESCRIBED LEARNING OUTCOMES
Students will...
5-3-13 Compare devices that use variations of simple machines to accomplish similar tasks. *Examples: a short- or long-handled pump, a racing or mountain bicycle...* GLO: B1, C3, C4, D4
5-0-7f Use prior knowledge and experiences selectively to make sense of new information in a variety of contexts. GLO: A2, C4 (ELA Grade 5, 1.2.1) **5-0-8c** Recognize that technology is a way of solving problems in response to human needs. GLO: A3, B2 **5-0-8d** Provide examples of technologies from the past and describe how they have evolved over time. GLO: B1

SUGGESTIONS FOR INSTRUCTION

➢ Comparison

Provide students with thin, long-bladed scissors; thick, short-bladed scissors; a child's scissors (blunt end, small); and other scissors, as available. Have students

- test to determine which pair of scissors is best for cutting plain paper, for cutting fabric, and for cutting cardboard
- describe the scissors using the term *lever* (Scissors are a combination of two levers. The force is applied at the handles, the fulcrum is where the two blades are connected, and the load is whatever is being cut. The closer the load is to the fulcrum, the easier it is to cut. For example, the thick, short-bladed scissors will cut thicker paper better than will the thin, long-bladed scissors.)
- explain why there are so many different types of scissors (They are used for different purposes.)

➢ Past and Present

Have students identify a simple machine used in the past and trace its development to the present day, highlighting major improvements (e.g., a bicycle).

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

Prescribed Learning Outcomes

Students will...

5-3-14 Use the design process to construct a prototype containing a system of two or more different simple machines that move in a controlled way to perform a specific function.

GLO: C3, D4, E2

5-0-1c Identify practical problems to solve. *Examples: How can I determine the mass of air? Which prepared pizza should I buy?…* GLO: C3

5-0-1d Identify various methods to solve a practical problem, and select and justify one to implement. *Examples: constructing and testing a prototype; evaluating consumer products; accessing information from a variety of sources...* GLO: C3 (Math: SP-II.1.5)

5-0-2a Access information using a variety of sources. *Examples: libraries, magazines, community resource people, outdoor experiences, videos, CD-ROMs, Internet…* GLO: C6 (ELA Grade 5, 3.2.3; Math: SP-II.3.1)

5-0-3d Develop criteria to evaluate a prototype or consumer product. Include: function, aesthetics, use of recycled materials, cost, reliability. GLO: C3

5-0-3e Create a written plan to solve a problem. Include: materials, safety considerations, labelled diagrams of top and side views, steps to follow. GLO: C1, C3, C6

5-0-4b Construct a prototype. GLO: C3

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

5-0-6d Identify and make improvements to a prototype, and explain the rationale for the changes. GLO: C3, C4

5-0-7d Propose and justify a solution to the initial problem. GLO: C3

5-0-9c Demonstrate confidence in their ability to carry out investigations. GLO: C5

Suggestions for Instruction

➢ **Design Process Project**

Provide students with the following:

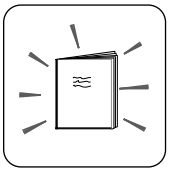
1. Select one chore that you dislike doing. Using the design process, invent a machine that will help make this chore easier. Your machine must use at least two different simple machines and must be able to be used repeatedly.
2. You have been invited to the Simple Machine Symposium, at which you will demonstrate the workings of your invented machine and explain the process that you followed to make it work.

   Students may use the "Design Project Report" (BLM 5-H) to record their work.

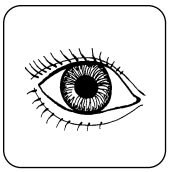
Refer to page 16 of this document for a description of the design process.

Suggestions for Assessment

Refer to the following BLMs for assessment suggestions:



"Design Project Report: Assessment" (BLM 5-I)



"Constructing a Prototype: Observation Checklist" (BLM 5-G)

Suggested Learning Resources

Design and Technology System (Design Process Reference and Tools)

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

Notes