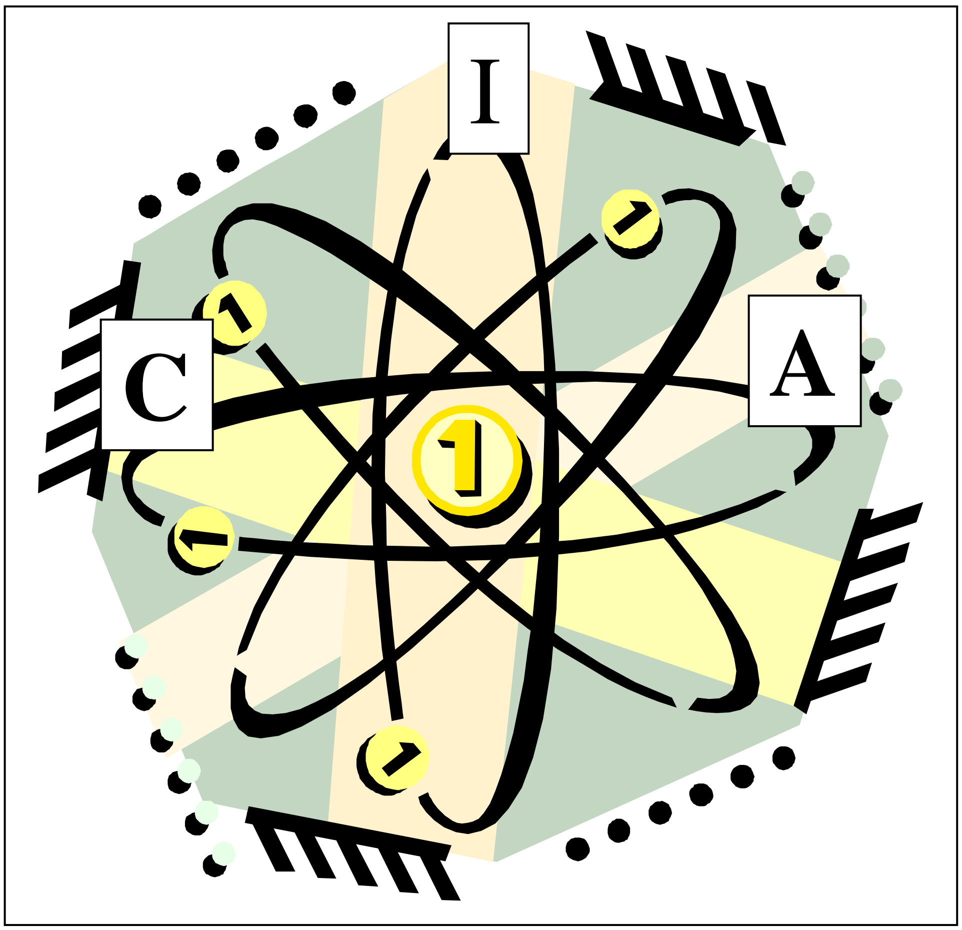
Curriculum, Instruction, Assessment (CIA) Alignment

Science, Grade 3
Unit 2: Simple Machines

Task Analysis and Hands-on Investigations



Ronald Blocker, Superintendent
Orange County Public Schools
Orlando, Florida

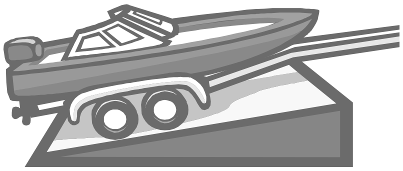
2003-2004

Subject Area: Science
Strand C: Force and Motion
Grade: 3

Benchmarks

SC.C.1.2.1: The student understands that the motion of an object can be described and measured. SC.C.2.2.1: The student recognizes that forces of gravity, magnetism, and electricity operate simple machines. SC.C.2.2.2: The student knows that an object may move in a straight line at a constant speed, speed up, slow down, or change direction dependent on net force acting on the object.

TASK ANALYSIS **The student…**
SIMPLE MACHINES
• demonstrates that work is done every time a force is used to move something.
• identifies the six types of simple machines (screw, inclined plane, wedge, pulley, lever, wheel and axle).
• demonstrates how simple machines are used to accomplish work.
• describes the motion of various objects (e.g., forward, circular, wave).
• measures the distance traveled by various objects.
• classifies the motion of an object as traveling in a straight line at a constant speed, speeding up, slowing down, or changing direction.
• experiences that the greater the force, the greater the change in the motion of an object.



ARE YOU SO INCLINED?

BENCHMARK and TASKS

SC.C.2.2.1 The student recognizes that forces of gravity, magnetism, and electricity operate simple machines.

- The student demonstrates that work is done every time a force is used to move something.
- The student identifies the six types of simple machines (screw, inclined plane, wedge, pulley, lever, wheel and axle).
- The student demonstrates how simple machines are used to accomplish work.

KEY QUESTION

How do we use inclined planes, screws, and wedges to help us accomplish work?

BACKGROUND INFORMATION

Machines are mechanical devices that often permit people to do work more easily. Work is done any time a **force** is used to move an object.

There are six types of simple machines – machines with few, if any, moving parts: **lever**, **wheel and axle, inclined plane**, **pulley**, wedge, and screw. An inclined plane enables an object to be moved with less force. An inclined plane, such as a ramp or a sliding board, is a simple machine that has no moving parts. The use of a ramp makes it easier to move objects up and down over a distance. The angle of an inclined plane affects how much force is needed to move a load up or down. The greater the angle of the incline, the greater the amount of force needed. Stairs and escalators are inclined planes. An inclined plane enables us to use less force to do about the same amount of work by distributing the force over a greater distance. A screw is an inclined plane wrapped around a shaft. Jar lids, bolts, and drills are screws. A wedge is also a modified incline plane. A wedge is usually made up of two inclined planes placed back to back. Wedges are used to separate two objects from each other or to split a solid object. Force is applied to the wide end of the wedge, which forces the narrow end into the object. The object widens at this opening, thus allowing the wedge to penetrate deeper each time force is applied. Nails, knives, and pins are wedges.

A spring scale is the instrument we use to measure the weight of an object. Weight is the gravitational force pulling an object towards the center of the earth. If weight is the force of **gravity** acting on an object when we measure weight, we are really measuring force acting on the spring. We can measure force by observing how far a spring stretches if we know how far it will stretch for a certain force or load. Most spring scales have two scales so you can measure weight in grams and force in newtons.

MATERIALS

Per group

markers
tape
markers
1 flat board or other surface for the inclined plane
1 spring scale
6 or more books of the same thickness
scissors
1 strong, zipper-type baggie
1 paper clip
Are You So Inclined? data sheet
1 metric ruler
1 cup of popcorn kernels or rice
(or other mass, such as metal washers)

Per student

half sheet of paper
pencil

Teacher

1 pulley
1 pair of scissors
1 nail
1 jar with screw type lid
1 ramp
1 toy car with a wheel and axle
Early Bird Physics Books, Sally M. Walker and Roseann Feldman, Lerner Publications Co., 2002
Simple Machines, Lola M. Schaefer, Benchmark Education Co.

TEACHING TIPS

1. Give students ample time to explore with spring scales before doing the activity. Explain that force can be measured in units called newtons (N). Have students locate the N scale on the spring scales before starting the activity.
2. Folded game boards (e.g., Monopoly, checkers) can be used as inclined planes.

ENGAGE

1. Display a ramp, a pulley, a jar with a screw-type lid, a pair of scissors, a toy car with a wheel and axle, and a nail. Ask students to think about what these items have in common. After allowing time for students' responses, explain that these are all examples of simple machines (ramp – inclined plane, pulley, screw-type lid – screw, scissors – lever, toy car - wheel and axle, and nail – wedge). Ask: *Why do you think people use machines?* Explain that machines are mechanical devices that allow people to accomplish work. Sometimes they save time and/or energy.
2. Share the book, *Simple Machines*, by Lola M. Schaefer
3. Tell students there are six types of simple machines: the lever, the wheel and axle, the inclined plane, the pulley, the wedge, and the screw. Write these on a chart in the form of a Tree Map. As students discover examples of these simple machines, they can be added to the Tree Map throughout the unit of study.

4. Explain that in this activity students will be exploring three of the six types of simple machines: inclined plane, wedge, and screw.

EXPLORE (Part 1)

1. Distribute the materials and record sheet to each group. Allow time for students to explore the spring scales. Teach them how to read the spring scale in newtons, units of force.
2. Have students fill the baggie with one cup of popcorn kernels or rice. Attach a paper clip to the top of the baggie. This will be the load.
3. Show students how to attach the spring scale to the paper clip on the baggie. Have each group stack 2 books and place the board at an angle to create an inclined plane.
4. Tell students to pull the baggie slowly and evenly up the inclined plane. The spring scale should still be attached. Students should pull the spring scale keeping it parallel to the incline. Remind students to observe the spring scale and record the measurement in newtons on the chart.
5. Instruct students to repeat the process using 4 and then 6 books to increase the angle of the inclined plane. (Use additional books, if the books are not thick enough.) After each pull, students should record the measurement in newtons on the chart.
6. Finally, students will slowly lift the spring scale to raise the attached load straight up as high as the top of the stack of 6 books. This will allow them to compare a straight-up lift to a lift using an inclined plane. Students should read the measurement on the spring scale in newtons and record this amount of force on their chart.
7. Have students measure the length of the ramp in centimeters.
8. Then have students measure the height of the stack of 6 books in centimeters. Compare the two measurements.

EXPLAIN (Part 1)

Which incline required the least amount of pulling force? Why do you think so? (The 2-book incline required the least amount of force because it was not as steep.)
Which incline required the most amount of pulling force? Why do you think so? (The 6-book incline required the most amount of force because it was steeper than the other two.)
How does the angle of an inclined plane affect the amount of force needed? (The steeper the angle, the more force is required.)
What was the reading on the spring scale on the straight up lift with no inclined plane?
How does the amount of force required to lift an object straight up compare to the amount of force required when an inclined plane is used to lift an object to the same height? (Less force is required when an inclined plane is used.)
Which covered a greater distance – lifting the load straight up or pulling the load up the incline? (The load was moved a greater distance when it was pulled up the inclined plane than when it was lifted straight up, but less force was required. An inclined plane enables us to use less force to do about the same amount of work by distributing the force over a greater distance.)
Was any work done when the baggie was pulled up the inclined plane? (Yes, because a pulling force was used to move the baggie.)

EXPLORE (Part 2)

1. Give each group: a half sheet of paper, scissors, tape, and a pencil. Tell students they are going to make a model of another simple machine – the screw.

2. Demonstrate as you instruct students how to make the model of a screw. Tell students to begin by making a small dot in one corner of the paper.
3. Measure 20 cm along one edge from the dot and make an X. Measure 10 cm along the other edge from the dot and make an X.
4. Then have students use a ruler to draw a straight line from X to X so that they have a triangle.
5. Students should trace the line with a marker so that it can be easily seen and then cut just outside the line.
6. Ask: Wh*at simple machine does this triangle look like?* (A screw is a modified inclined plane!)
7. Place one plain edge of the triangle next to a pencil, making sure you can see the colored line.
8. Wrap the triangle tightly around the pencil and tape the end.

EXPLAIN (Part 2)

What does this look like? (a large screw)
How does it resemble a screw? (The colored line looks like lines wrapped around the screw. It looks like more than one line, but it is only one – just like the threads on a screw. You can trace it without lifting your finger.)
How is a screw different from a nail? (A nail has no threads.)
What was it before we wrapped it around the pencil? (an inclined plane)
Where are some places screws are used? (screw-type jar lids, door hinges)
How do screws make our work easier? (Turning a screw with many thread lines is like walking up a long slope. The screw has to be turned more times, but each turn takes less force. That makes your work easier.)

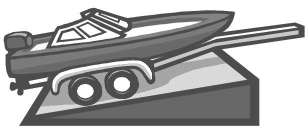
EXTEND AND APPLY

1. Hold up a doorstop or another type of wedge and ask students to describe the object. Students will likely mention that it resembles an inclined plane. Explain that a wedge is really two inclined planes put together. A wedge's pointed end makes it easier to move things apart. It would be very hard to hammer a nail into wood if its tip were not wedge-shaped. The wedge-shaped tip makes it easier because the wedge pushes the wood apart. Ask students if they can think of some other examples of wedges that can be added to the Tree Map.
2. Share the *Early Bird Physics Books*. The titles include: *Work, Inclined Planes, Screws, Wedges, Levers, Pulleys, and Wheels and Axles.*

ASSESSMENT

Have students list one or more examples of an inclined plane, a screw, and a wedge and explain how each one helps us to accomplish work.

NAMES ____



ARE YOU SO INCLINED?

Directions: Use this chart to record the data from your investigation.

DEGREE OF INCLINE	AMOUNT OF FORCE REQUIRED (newtons)
2 Books	
4 Books	
6 Books	
Straight Up (Height of 6 books)	

1. Which requires more force – lifting an object straight up to a certain height or using an inclined plane to lift an object to a certain height?

   ____

2. Measure the height of the stack of 6 books in centimeters. ____________

3. Measure the length of the ramp in centimeters. ____________________

4. Which covers a greater distance – lifting the baggie straight up or using the ramp? ____

THE CLEVER LEVER

BENCHMARK and TASKS
SC.C.2.2.1 The student recognizes that forces of gravity, magnetism, and electricity operate simple machines.

- The student demonstrates that work is done every time a force is used to move something.
- The student identifies the six types of simple machines (screw, inclined plane, wedge, pulley, lever, wheel and axle).
- The student demonstrates how simple machines are used to accomplish work.

KEY QUESTION
How will shifting the load on a lever affect the amount of force needed to lift it?

BACKGROUND INFORMATION
Machines are mechanical devices that often permit people to do work more easily. Work is done any time a **force** is used to move an object. There are six types of simple machines: **lever, wheel and axle, inclined plane, pulley**, wedge, and screw**.**

A lever has four parts: a bar or beam, the **fulcrum** (the fixed point around which the bar pivots), the load (the object to be moved), and the effort (the force needed to move the load). Some common examples of a lever are: crowbar, shovel, claw, the hammer when use for prying, hinged door, wheelbarrow, fishing rod, baseball bat, and broom. One of the simplest examples of a lever is the playground seesaw. Levers can be used to decrease the amount of force needed to do a certain amount of work.

MATERIALS

Per pair of students
1 metric ruler
fulcrum (1 thick, round marker)
3 small ceramic tiles (taped)
The Clever Lever record sheet
20 interlocking cubes

Per class
tote bag with a handle
several books
Early Bird Physics Books, Sally M. Walker and Roseann Feldman, Lerner Publications Co., 2002

TEACHING TIPS
1. Instruct students to be careful when pushing on the lever. They should push slowly and gently with the index finger.
2. Washers or pennies could be substituted for the ceramic tiles.

ENGAGE

1. Remind students that there are six types of simple machines: lever, wheel and axle, inclined plane, pulley, wedge, and screw. Refer to the Tree Map the class started in the previous activity when they were investigating inclined planes. Tell students they are going to learn about another simple machine, the lever.
2. Tell students they have their own body levers – their arms and legs! Ask a student volunteer to come forward and hold his arm out straight. Put the tote bag handle on his wrist. Using his shoulder as the fulcrum, he should try to lift the bag without bending his arm.
3. Then move the handle up to his elbow. Have him again lift the bag with a straight arm. Ask if it is easier or harder to lift than when it was hanging from his elbow.
4. Finally, move the handle up toward his shoulder. Have him again lift the bag with a straight arm. Ask if it is easier or harder to lift now.
5. Ask: *At what point was the bag the easiest to lift?* Allow all students to experience that the closer a load is to the fulcrum, the easier it is to lift!

EXPLORE (Part 1)

1. Distribute tiles, a metric ruler, and a marker to each group. Have students tape the marker (fulcrum)to the desk and then place the ruler across the fulcrum so the 15-cm mark is centered on the fulcrum. Have students tape the three tiles together and then place the taped tiles at the 20-cm position on the ruler.
2. Explain that a lever has four parts: a bar or beam (the ruler), the fulcrum or object on which the bar pivots (the marker), the load or the object to be moved (the three taped tiles), and the effort or force needed to move the load (the index finger).
3. Give each group *The Clever Lever* record sheet. Ask students to make a prediction about where it will be the easiest to lift the load – at the 20 cm, 25 cm, or 30 cm mark on the ruler. Predictions should be made by ranking the positions as 1, 2, or 3, with 1 being the position at which the load will be the easiest to lift.
4. Have students take turns lifting the load, using only their index finger at the 1 cm mark to provide a pushing force.
5. Next, have the students place the load at 25 cm and take turns using their index finger to lift the load.
6. Finally, have the students place the load at the 30 cm mark and take turns using their finger to lift the load.
7. Students should then record their results, again ranking the positions 1, 2, or 3, with 1 being the position at which the load was the easiest to lift.

EXPLAIN (Part 1)

At what position was it the easiest to lift the tiles? (20 cm)
At what position did it require more force to lift the tiles? (30 cm)

EXPLORE (Part 2)

1. Students should think about how many interlocking cubes would be needed to lift the 3 tiles at the 20-cm position and then write their prediction in the second table on *The Clever Lever* data sheet.
2. Next, students will find out exactly how many cubes it would take to lift the 3-tile load at the 20 cm position. (Note: Students should predict at only one position and then find the exact

number of cubes needed before moving on to the next position. This will enable them to use the data they are collecting to make more accurate predictions.)

3. Instruct students to repeat Steps 1 and 2 at the 25 cm and then the 30 cm marks.

EXPLAIN (Part 2)

How did the number of cubes needed for lifting the tiles at each position compare to your earlier findings?
Did the load position that was the easiest when you used only your finger also require the fewest number of tiles?
Did the load position that required the most force when you used only your finger also require the most tiles?
Was any work being done? (Yes, the pushing force of our finger was used to lift a load, the tiles.)
What does this investigation teach us about levers? (The closer a load is to the fulcrum, the easier it is to lift.)
What is the purpose of a lever? (A lever can help us pry things loose or lift heavy objects.)

EXTEND/APPLY

1. Ask: *How does a door act as a fulcrum?* Explain that the fulcrum of a door is the hinged part because that's the part the door pivots around. A door is like a large lever with nothing on one side of the fulcrum.
    - Adjust a door so that it is slightly ajar. Have a student volunteer use one finger near the hinges to gently push the door open. (Take care that the student does not place her fingers near the hinged opening!) Then have the student use one finger to gently push the door open near the handle.
    - Ask the student to tell the class which method was easier. (The farther from the fulcrum you push, the more force you create and the easier it is to open and close the door.)
2. Share the *Early Bird Physics Books*. The titles include: *Work, Inclined Planes, Screws, Wedges, Levers, Pulleys, and Wheels and Axles.*

ASSESSMENT

Show the students a manual can opener and a can. Say: *Imagine that you are using this manual can opener. You place the opener on the can like this, and you are about to open it, but stop and think: Would it be easier to puncture the can by squeezing the handle at the halfway mark or at the end? Why do you think so?*

Student investigators ____

THE CLEVER LEVER

1. Predict at which position the load will be the easiest to lift. Rank order the positions at which the load will be placed as 1, 2, or 3 with 1 being the easiest.
2. Record your findings by again rank ordering the positions as 1, 2, or 3 with 1 being the easiest.

Position of the Load	Load	Force	Prediction (1, 2, or 3)	Result (1, 2, or 3)
20 cm	3 tiles	finger		
25 cm	3 tiles	finger		
30 cm	3 tiles	finger		

3. Predict how many interlocking cubes it will take to lift the 3 tiles at each position.
4. Connect interlocking cubes and find the fewest number of cubes it will take to lift the 3 tiles at each level.

Position of the Load	Load	Force	Prediction (# of cubes to lift the load)	Result (# of cubes to lift the load)
20 cm	3 tiles	finger		
25 cm	3 tiles	finger		
30 cm	3 tiles	finger		

5. Explain how moving the load closer to or farther away from the fulcrum affects the amount of force needed to lift the load.

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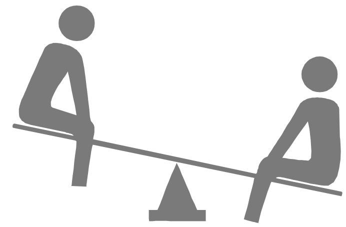
LIFTING WITH LEVERS



BENCHMARK and TASKS
SC.C.2.2.1 The student recognizes that forces of gravity, magnetism, and electricity operate simple machines.

- The student demonstrates that work is done every time a force is used to move something.
- The student identifies the six types of simple machines (screw, inclined plane, wedge, pulley, lever, wheel and axle).
- The student demonstrates how simple machines are used to accomplish work.

KEY QUESTION
How is a lever like a playground seesaw?

BACKGROUND INFORMATION
Machines are mechanical devices that often permit people to do work more easily. Work is done any time a **force** is used to move an object. There are six types of simple machines: **lever, wheel and axle, inclined plane, pulley**, wedge, and screw.

A lever has four parts: a bar or beam, the **fulcrum** (an object on which the bar pivots), the load (the object to be moved), and the effort (the force needed to move the load). Examples of levers are: crowbar, shovel, claw, the hammer when use for prying, hinged door, wheelbarrow, fishing rod, baseball bat, and broom. One of the simplest examples of a lever is the playground seesaw. Levers can be used to decrease the force needed to do a certain amount of work.

MATERIALS

Per pair of students
1 metric ruler
6 pennies
fulcrum (1 thick, round marker)
tape
Lifting with Levers data sheet
1 toothpick or pencil
1 balance

Per class
Early Bird Physics Series, Sally M. Walker and Roseann Feldman, Lerner Publications Co., 2002

ENGAGE
Discuss students' prior experiences with seesaws by asking the following questions:
Have you ever ridden a seesaw?
How do two people of the same size ride a seesaw?
How can two people use the seesaw when the person on one side of the seesaw is much heavier than the other person? (The heavier person must move closer to the middle – the fulcrum.)

EXPLORE

1. Distribute materials to each group.
2. Have students tape the thick marker to the table.
3. Students should place the metric ruler down on the marker and then move the ruler until the ruler is balanced. (Students should note the point of balance, which will be at approximately the 15-cm mark.) The marker is the fulcrum.
4. Students should tape 3 pennies together with a small piece of tape and place the taped stack of pennies on the 11 cm mark of the ruler. Then they should place another stack of 3 pennies (not taped) on the other side of the ruler.
5. Have students use a toothpick or a pencil to move the untaped stack of pennies to the position on the ruler where it just lifts the taped 3-penny load on the other side. (The lever may not be perfectly balanced.) Instruct students to record this position on their chart.
6. Students should keep the taped 3-penny load on the 11-cm mark. Next, they should remove one of the untaped pennies and use only 2 pennies to see where on the ruler the 2-penny stack just lifts the taped 3-penny load. Instruct students to record this position on their chart.
7. Finally, students should use only 1 penny to see if they can find a place on the ruler where it can just lift the taped 3-penny load, still at the 11-cm mark. Instruct students to record the results on their chart.

EXPLAIN

Which part of the lever was the beam? (ruler)
What part of the lever was the fulcrum? (marker)
What part of the lever was the load? (3 pennies taped together)
When you used fewer pennies to lift the 3-penny load, did you move them closer to or farther away from the fulcrum? (As fewer pennies are used, they can still lift the 3-penny load if they are moved farther from the fulcrum.)
How is this like children on a seesaw? (A small child can lift a much larger child if they sit at different distances along the seesaw. The weight of the children and their distance from the fulcrum are the two variables in balancing the seesaw. If one child weighs twice as much as the other, to balance the seesaw, the smaller child must be twice as far from the fulcrum as the heavier child.)
What does the data on your chart tell us about levers? (The greater the load, the closer the effort is to the fulcrum. The lighter the load, the farther away from the fulcrum the effort is.)
Was any work being done? (Yes, because force was used to actually lift the 3-penny load.)

EXTEND/APPLY

1. The balance is an example of a lever. Give students time to explore the balance: Ask: *Where is the fulcrum? What is the load? What part acted as the effort or force?*
2. Encourage students to find other examples of levers in the classroom, at school, and at home. Identify the parts of the levers.
3. Share the *Early Bird Physics Books*. The titles include: *Work, Inclined Planes, Screws, Wedges, Levers, Pulleys, and Wheels and Axles.*

EXTENSION

Have students measure the distances from the pennies to the fulcrum. Then they can multiply the number of pennies times the distance to the fulcrum and see whether the products are the same on both sides of the fulcrum. For example, the 3 taped pennies were always at 11 cm which was approximately 4 cm from the fulcrum (3 x 4 = 12). Students would need to multiply the number of pennies on the other side of the fulcrum times their distance from the fulcrum. (Note: The exact mathematical relationship between the number of pennies and the distance from the fulcrum is complicated by the fact that not all pennies have the same mass.)

ASSESSMENT

Tell students you need to dig up a large rock, but the rock is too heavy to lift. Have them explain how a lever might help you accomplish this task.

Student investigators ____

LIFTING WITH LEVERS

Number of Pennies in the Taped Stack	Position on the Ruler	Number of Pennies in the Untaped Stack	Position on the Ruler Where the Untaped Pennies Just Lifted the 3-Penny Load
3 pennies	**11 cm**	**3 pennies**	
3 pennies	**11 cm**	**2 pennies**	
3 pennies	**11 cm**	**1 penny**	

Complete the chart and then explain what the numbers in the table tell us about levers.

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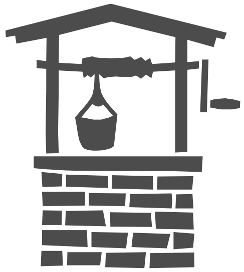
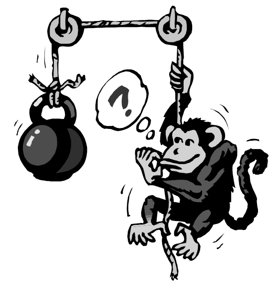


PULLEY POWER



BENCHMARK and TASKS

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- The student demonstrates how simple machines are used to accomplish work.

KEY QUESTION

How can pulleys make our work easier?

BACKGROUND INFORMATION

Machines are mechanical devices that often permit people to do work more easily. Work is done any time a **force** is used to move an object. There are six types of simple machines: **lever, wheel and axle, inclined plane, pulley,** wedge, and screw.

The pulley is a wheel with a groove along the edge of the wheel to hold a line or rope. Using a single, fixed pulley (a pulley that stays attached in one place, as in this activity) allows the direction of the force to be changed. When we pull down, the load is moved up. The amount of force needed to lift the tiles will be about the same both with and without a pulley. However, it will be easier to lift the tiles because pulling the rope down is easier than lifting the load up. Pulleys may be movable or fixed. They are used to raise flags, open and close drapes, lift heavy objects, create a movable clothesline, etc.

A spring scale is the instrument we use to measure the weight of an object. Weight is the gravitational force pulling an object towards the center of the earth. If weight is the force of **gravity** acting on an object when we measure weight, we are really measuring force acting on the spring. We can measure force by observing how far a spring stretches if we know how far it will stretch for a certain force or load. Most spring scales have two scales so you can measure weight in grams and force in newtons.

MATERIALS

Teacher

1 broom or other long, strong dowel
1 meter of rope
1 bucket of blocks, books, or heavy objects
Early Bird Physics Series, Sally M. Walker and Roseann Feldman, Lerner Publications Co., 2002

Per group

1 single pulley
15 ceramic tiles or metal washers
1 spring scale
3 ft. pulley cord or rope
1 strong, zipper-type baggie
1 paper clip

TEACHING TIPS

1. Make sure the rope or cord fits into the groove of the pulleys being used.
2. Make sure students have had experiences using spring scales. If not, you will need to allow time for exploration and instruct them in how to read a spring scale.

ENGAGE

Show students the bucket of books. Lift the loaded bucket up as high as the seat of a chair. Ask the students for suggestions as to how you might make this work easier. Let students demonstrate their ideas. Demonstrate how to use the broomstick and rope to lift the bucket an easier way:

- Place the broom handle across the back of two chairs set about two feet from each other.
- Tie the rope to the handle of the bucket and drape it over the broom handle.
- Pull down on the loose end of the rope to lift the bucket up to the height of the chair seat.
- Let students who demonstrated other methods now try to lift the bucket this way.
- Discuss which way seemed easier.
- Explain that this was a simplified model of a pulley, one kind of simple machine. Remind students that there are six types of simple machines: lever, wheel and axle, inclined plane, pulley, wedge, and screw. Refer to the Tree Map the class has been keeping and tell students you will be adding examples of pulleys.

EXPLORE

1. Show students the pulleys. Demonstrate how to set up a pulley system, using the pulley, the rope, and the spring scale. Discuss the pulleys that are to be used; some may have clamps while others may have hooks for hanging. Discuss the various places and ways students could set up the pulleys. Pulleys with hooks could hang from ring stands. Pulleys with clamps could be clamped to many different surfaces. One team member could hold the pulley.
2. Distribute materials to each group. Have students put 15 tiles inside the baggie, close it, attach a paper clip, and then hook it to the spring scale. This will be the load.
3. Show students how to lift the baggie straight up by slowly pulling up on the spring scale. Make sure students observe the spring scale while lifting the baggie. Ask: *How much force is needed to lift the tiles?* Have students record the force in newtons on the *Pulley Power* sheet.
4. Help each group set up a pulley system to lift the baggie containing 15 tiles. Once a pulley system has been constructed, have students attach the spring scale and measure the force required to lift the baggie containing 15 tiles.
5. Have students lift a baggie containing 10 tiles straight up without a pulley and with a pulley. Each time, the spring scale should be used to measure the units of force required, and the measurement should be recorded on the *Pulley Power* record sheet.
6. Finally, students will lift a baggie containing 5 tiles straight up without a pulley and with a pulley and record the measurements on the *Pulley Power* sheet.

EXPLAIN

Which way was easier to lift the baggie - straight up or with the pulley?

When you used the pulley, which way did you pull - up or down? (down – The pulley changes the direction of the force.)
How did the measurements on the spring scale differ with and without the pulley each time? (**The amount of force needed to lift the load of tiles will be approximately the same both ways,** but it will be easier to lift with the pulley because pulling down on the rope is easier than lifting up the load. The pulley changes the direction of the force.)
Was any work accomplished? (Yes, because force was used to move the baggie of tiles.)
How are pulleys used to help us accomplish work?

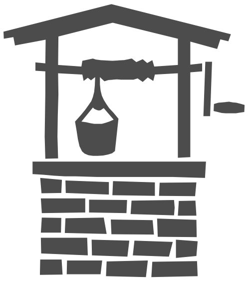
EXTEND/APPLY

1. Take a walk around the school so students can look for pulleys. Discuss why the pulleys are being used and how they work.
2. Arrange for the class to have a demonstration of how the flag is raised and lowered.
3. Share the *Early Bird Physics Books.* The titles include: *Work, Inclined Planes, Screws, Wedges, Levers, Pulleys, and Wheels and Axles.*

ASSESSMENT

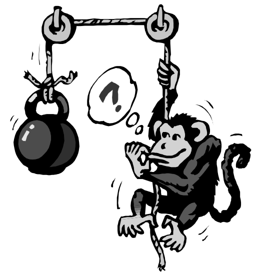
Have students reflect in their journals: *How can pulleys make our work easier?*

Investigators ____

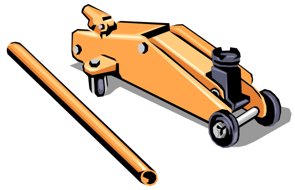


PULLEY POWER

Directions: Use this chart to record the data from the investigation.



LOAD	LIFT	AMOUNT OF FORCE REQUIRED (newtons)
15 tiles	Without Pulley	
15 tiles	With Pulley	
10 tiles	Without Pulley	
10 tiles	With Pulley	
5 tiles	Without Pulley	
5 tiles	With Pulley	



ON A ROLL

BENCHMARKS and TASKS

SC.C.1.2.1 The student understands that the motion of an object can be described and measured.
SC.C.2.2.2 The student knows that an object may move in a straight line at a constant speed, speed up, slow down, or change direction dependent on net force acting on the object.

- The student demonstrates that work is done every time a force is used to move something.
- The student identifies the six types of simple machines (screw, inclined plane, wedge, pulley, lever, wheel and axle).
- The student describes the motion of various objects (e.g., forward, circular, wave).
- The student measures the distance traveled by various objects.
- The student classifies the motion of an object as traveling in a straight line at a constant speed, speeding up, slowing down, or changing direction.
- The student experiences that the greater the force, the greater the change in the motion of an object.

KEY QUESTION

How do toy cars move down an inclined plane?

BACKGROUND INFORMATION

A **force** is a push or a pull on an object. Forces can affect objects in several ways. For example, forces acting on a stationary object can set the object in motion or they can change a moving object's speed and/or the direction in which it's moving. A force can also affect an object by just changing its shape. More than one force can act on an object at the same time. Sometimes these forces are applied in the same direction; sometimes they are applied in different directions. The net force on an object is the combination of all the forces acting on it.

Motion can be described as a change in an object's position. It takes force to change an object's motion. The greater the force is, the greater the change in motion will be. The more massive an object is, the less effect a given force has. Something in motion will move in a straight line forever without slowing down unless a force acts on it.

Friction is the force that opposes motion between two surfaces that are in contact with each other. Friction might prevent motion from starting, or it might oppose motion in progress.

Gravity is the force of attraction between objects that have **mass**. Since all objects have mass, gravity acts between all objects. The strength of gravity between two objects depends on two things: the mass of the objects and the distance between them. In this activity, the car accelerates as it moves down the ramp. This acceleration is due to the effect of gravity pulling the car down. Gravity pulls all objects towards the center of the earth with a force we call weight.

MATERIALS

Per group

1 flat board or other surface for the ramp
1 toy car (per student)
1 tongue depressor (optional)
On a Roll activity sheet

1 meter stick books stacked 2-3 inches high for the ramp

TEACHING TIPS

1. Set up a ramp for demonstration purposes before the activity.
2. Let students know in advance that they should bring a favorite toy car or truck – small enough to be used on the ramps. Have some extra cars on hand for those students who do not bring a car.
3. The ramps will need to be set up on a smooth surface, because the cars will roll down the ramp and stop immediately if they roll onto carpet.
4. Folded game boards (e.g., Monopoly, checkers) can be used as inclined planes.

ENGAGE

Ask students if they have ever played on a sliding board on a playground. Encourage a few students to share their experiences. Ask: *What caused you to move from the top to the bottom of the slide? What made you eventually stop sliding?*

EXPLORE

1. Have students set up a ramp using books stacked 2-3 inches high for a base and a game board or other flat piece for the ramp. The ramp should be set up on a smooth surface, such as the floor or the table. (If students use the table, they may have to make adjustments if the cars roll beyond the edge.) The ramp should be taped to the top book so that it will not slide out of position after each trial.
2. Distribute the activity sheet and materials to each group.
3. Explain that students should take turns placing their cars at the top of the ramp and letting them roll down. Students are not to push the cars; they should just release them. (A piece of stiff cardboard or a tongue depressor could be held in front of the cars and then quickly removed to allow the car to roll without pushing.)
4. Each car should be given three trial runs.
5. The measurement of the distance rolled should be taken from the end of the ramp to the far or back edge of the car. (If the car curved, the student should be careful to keep the meter stick straight when measuring.) Record the measurement each time.
6. Find the median number of the three trials.

EXPLAIN

What type of simple machine is a ramp? (inclined plane)
What was the order of the cars according to the distance they rolled?
Which car rolled the farthest?
Which car rolled the least distance?
What may have caused the difference in distances rolled? (The mass of the cars will make a difference.)
Describe the motion of each car as it rolled. Did the car roll forward in a straight line or did it curve?
At any point, did the car seem to speed up, slow down, or change direction?
What force slowed down the motion of the car and eventually caused it to stop rolling? (friction)
Was any work done? (Gravity caused the car to move down the inclined plane.)

EXTEND/APPLY

1. Ask: *Do you think the height of the ramp makes a difference in the distance the cars roll?*
   - Have students change the height of the ramp by adding more books or by removing some books. Students should repeat the activity exactly as they did it before.

- Ask: *Did the height of the inclined plane increase the distance the car rolled?* (Yes, the cars have more stored (potential) energy with the greater height. The greater the force is, the greater the change in motion will be.)

2. Have each group send the student whose car traveled the farthest distance to a "roll off." First, have students observe the cars to see if they have any properties in common, compared to the other cars used. Repeat the activity with these cars to determine the car that rolls the greatest distance.

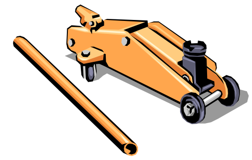
EXTENSIONS

1. Try a similar activity using full soda cans and empty soda cans instead of cars.
2. Have students ask other questions about toy cars and inclined planes and then allow them to carry out those investigations (e.g., Will the surface onto which the car rolls make a difference?).

ASSESSMENT

Have students write in their journals summarizing what they have learned about the motion of cars rolling down inclined planes.

Investigators ____



ON A ROLL

CAR	TRIAL 1	TRIAL 2	TRIAL 3	MEDIAN
1				
2				
3				
4				
5				