Kindergarten Forces and Motion Unit Learning Plan and Teacher's Guide

Lesson Sequence Overview

Number of Lessons: 4

NGSS:

K-PS2-1: Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object. *Examples of pushes and pulls could include a string attached to an object being pulled, a person pushing an object, a person stopping a rolling ball, and two objects colliding and pushing on each other. Assessment does not include magnets.*

K-PS2-2: Analyze data to determine if a design solution works as intended to change the speed of an object with a push or pull.* *Examples of problems requiring a solution could include having a marble or other object move a certain distance, follow a particular path, and knock down other objects. Examples of solutions could include tools such as a ramp to increase the speed of an object and a structure that would cause an object such as a marble or ball to turn. Assessment does not include friction.*

Lesson # and Title	**1: Strengths and Directions of Pushes and Pulls**	**2: Pushes, Pulls, and the Speed of Objects (Ramps)**	**3: Pushes, Pulls, and the Direction of Objects (Marbulous Challenge)**	**4: Pushes and Pulls with Simple Machines**
Lesson Type	Pre-Lab / Exploration	Inquiry Lab	Challenge / Engineering Lab	Challenge / Engineering Lab
Duration	45 min	60 min	45 – 60 min	45 – 60 min
Materials	• Word wall cards • Worksheet #1 • Teacher Resource Page #1 • Push/Pull cards • Various Toys	• Word wall cards • Worksheet #2 • Teacher Resource Pages #2a and 2b • Ramps • 5 Clear Shoeboxes, 3 with lids • Large Foam Ball • Medium, Heavy Ball (handball) • Marble • Dice • Pencil • Rock	• Word wall cards • Worksheet #3 • Teacher Resource Page #3 • 7 Marbulous sets • 1-3 Timers • 1-2 Parent Volunteers (to help with timing and to encourage teamwork)	• Word wall cards • Simple Machines GLAD style poster pages • Worksheet #4 • Wooden Simple Machines

Science Vocabulary: *Defined on word wall cards*

Balanced	Equilibrado
Change of motion	Cambio de movimiento
Direction	Dirección
Force	Fuerza
Friction	Fricción
Gravity	Gravedad
Left	Izquierda
Machine	Máquina
Mass	Masa
Matter	Material
Motion	Movimiento
Property	Propiedad
Pull	Tirón / Jalón
Push	Empujón
Ramp	la Rampa
Right	Derecha
Slope	Inclinación
Speed	Velocidad
Stable	Estable
Straight	Recto
Turn	Vuelta
Unbalanced	Desequilibrado
Unstable	Inestable

Kindergarten Forces and Motion
Lesson 1: Strengths and Directions of Pushes and Pulls – exploration

Objectives:

- To introduce and differentiate between a push and a pull on the direction of an object.

NGSS

- **K-PS2-1:** Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.

Materials/Teacher Setup:

- Copies of worksheet #1 for each student
- Toys on hand for each table group that can be pushed and pulled, for example toy cars, wagon, pull toys, etc
- Word wall cards ready: motion, change of motion, push, and pull
    - *Put into pocket chart or up on board with a magnet as they're introduced*
- Teacher Resource page #1 questions projected or pre-written onto white board
- Push/pull cards with tape on the back already

Lesson Outline: *Could be squeezed into 30 minutes, but 45 minutes recommended.*

Intro to Motion 5 minutes	Explain to class that today we will study MOTION. Ask students to think, pair, share: What is MOTION? What does something in MOTION look like? *Alternate idea using VTS: Use See, Think, Wonder to look at two different pictures. One where an object or living thing is still and motionless. Another photo where an object or living thing is clearly in motion.* Introduce MOTION and CHANGE OF MOTION word wall cards.
PUSH 5-10 minutes	Ask students to think, pair, share, about the PUSH questions on the board: What does it mean to PUSH an object? Does how hard I push it matter? If I PUSH something, where does it go? Ask students to show and share examples. Introduce PUSH word wall card, and explain how it connects to MOTION and CHANGE OF MOTION. Introduce PUSH hand motions, and say together: "When I PUSH an object, it moves AWAY from me." and/or "PUSH away"
PULL 5-10 minutes	Ask students to think, pair, share, about the PULL questions on the board: What does it mean to PULL and object? Does how hard I pull it matter? If I PULL something, where does it go? Ask students to show and share examples. Introduce PULL word wall card, and explain how it connects to MOTION and CHANGE OF MOTION, and how it is opposite of PUSH.
Explore 5-10 minutes	Give each table several toys, and ask them to play and discuss the focus questions. How can we PUSH or PULL these toys? Does how hard I PUSH or PULL matter? Where do they go when I push or pull? Introduce PLL hand motions, and say together: "When I PULL an object, it moves TOWARDS me." and/or "PULL towards"
Discussion and Extension 5-10 minutes	Ask 3 groups to share out and show how they PUSHED or PULLED their toys. Now ask each group to look around the room and identify objects in the room that can be PUSHED or PULLED. *For example: a drawer can be PULLED to open. A chair can be PUSHED in. etc.* Randomly call on students and ask them to stick a PUSH or PULL card onto an object in the room and explain how it can be pushed or pulled.
Conclusion 5 minutes	Pass out worksheets. Fill out and read together. Use hand motions when reading and describing push and pull.

Formative Assessment Discussion Questions

1) What is MOTION?

2) What does something in MOTION look like?

3) What does it mean to PUSH an object?

4) Does how hard I push it matter?

5) If I PUSH something, where does it go?

6) What does it mean to PULL an object?

7) Does how hard I pull it matter?

8) If I PULL something, where does it go?

Formative Assessment Discussion Questions

1) What is MOTION? When something moves. An object that changes position. Not still.

2) What does something in MOTION look like? When you move you are not still. You are not in one place. An object that is not at rest.

3) What does it mean to PUSH an object? To push is to move something away from you. To move something in or away.

4) Does how hard I push it matter? Yes. Bigger/stronger pushes can move things farther and faster.

5) If I PUSH something, where does it go? Pushing things move them away.

6) What does it mean to PULL an object? To pull is to move something closer to you, or towards you. You can also pull something behind you like a wagon.

7) Does how hard I pull it matter? Yes if an object is heavy you will have to pull it harder to bring it closer to you. The harder you pull the closer or faster it will come to you.

8) If I PULL something, where does it go? It comes towards you or closer to you.

Kindergarten Forces and Motion
Lesson 2: Pushes, Pulls, and the Speed of Objects (Ramps)

Objectives:

- To determine through guided inquiry that heavier objects and faster objects can give a stronger push.
- To determine through guided inquiry that a ramp is a simple machine that increases the speed and "push" of an object, and that the steeper the slope of the ramp, the greater the speed and push.

NGSS:

- **K-PS2-1:** Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.
- **K-PS2-2:** Analyze data to determine if a design solution works as intended to change the speed of an object with a push or pull.*

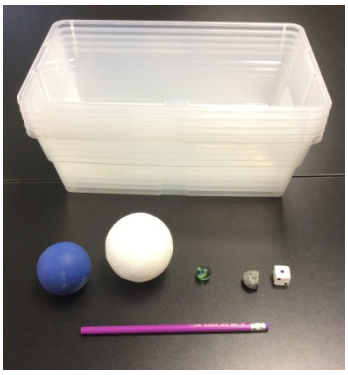
Teacher Background: This lab introduces the very basic understandings of Newton's Second Law of Motion through hands-on inquiry.

F=ma // Force = Mass x Acceleration

For kindergarten students, we break this down to **heavier objects,** (objects with more mass), and **faster objects (**objects with more speed as they move down the ramp, which is acceleration) can give a **stronger push (**produces more force).

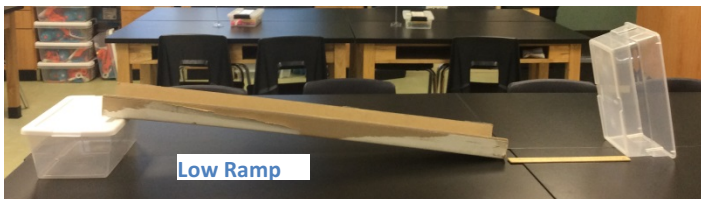
Heavier Objects (mass) **x Faster Objects (**acceleration) **= Stronger Push** (force)

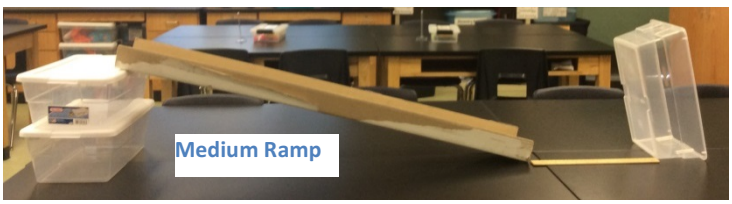
Instead of simply explaining this to students, we guide them through exploration with ramps and ask them probing questions so that they can reach this conclusion by the end of lesson on their own.



Materials & Teacher Setup: *use of the science lab recommended*

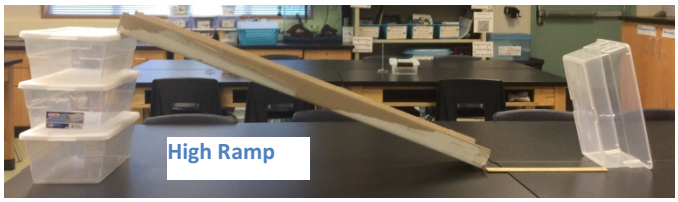
- Copies of worksheet #2 for each student.
- Gather materials
  - Ramps
  - Clear Shoeboxes (5 total, 3 for ramp height, 1 at bottom of ramp, 1 to hold objects. Tip: put the lids on the boxes used for the ramps, as they will stay in place more easily)
  - Large Foam Ball
  - Medium, Heavy Ball (handball)
  - Marble
  - Dice
  - Pencil
  - Rock





- Ruler (set up box at end of ramp one ruler length (30cm /12 inches) away for consistency)

- Teacher Resource Page #2.a Projected or written onto whiteboard, have #2.b ready for 2nd part of lesson.
- Have word wall cards MOTION, CHANGE OF MOTION, PUSH, PULL already on board or in pocket chart. Have other cards ready.
- Students in 6 groups.
- In front center of room, push 3 lab tables together for the ramp. Begin with Low Ramp set up. See pictures.



Lesson Outline: *60 minutes recommended, additional 15 for worksheet*

Intro 5 minutes	Introduce that this is our second lesson on motion. Think-pair-share on questions 1-4 on teacher resource page #2.a. After discussion of question 1, introduce the word wall card for SPEED. Continue discussion of questions 2-4, prompting students with questions to help them arrive at the conclusion that pushes and pulls can be given to objects to increase their speed.
Ramp Intro 10 minutes	Introduce the RAMP, SLOPE, and PROPERTY word wall cards to students. Ask them where they see a ramp in the room. (They should point to the ramp in the middle of the room.) Explain that each group is going to get a different object to test on the ramp. Provide 2 minutes to observe their groups' object, and answer questions 5 and 6. Ask each group to share out. Explain that in addition to just rolling down the ramp, we will observe whether the object has enough FORCE to PUSH over the box at the bottom of the ramp. Introduce the FORCE card, and ask students to discuss question 7 in groups. Lastly, ask students to predict at what SPEED the object will go down the ramp, question 8.
Ramp Testing: Low Ramp 10 minutes	Call up two students from the first group. (Go in the same order as the data table on teacher resource page 2.b to make it easier for students to follow along.) Ask the students to share their predictions. Have one student stand at the bottom of the ramp to "catch" the object. The other student will place the object at the top of the ramp. Emphasize that we want to see if the ramp will do the "push" for us, and NOT to push the object, just set it at the top of the ramp. Test each object twice, and then record the results on the data table, ensuring to involve the whole class. Rotate through each group until every object has been tested.
Ramp Testing: Medium Ramp 10 minutes	Add one clear plastic shoebox to the ramp to increase the height to medium. Ask students to repeat their predictions (questions 5-7) now that the ramp is higher. Choosing different students from each table group, repeat the testing and data recording process.
Ramp Testing: High Ramp 10 minutes	Add another clear plastic shoebox to the ramp to increase the height to high. Ask students to repeat their predictions (questions 5-7) now that the ramp is even higher. Choosing different students from each table group, repeat the testing and data recording process.
Conclusion	Give groups several minutes to discuss questions 8-10. Discuss each question

10 minutes	whole group, calling on different students to add to the conversation. While discussing questions 10 and 11 specifically, be sure to clarify the difference between BIG and HEAVY. The bigger ball is less heavy (has less mass) than the medium ball, and therefore gives a weaker push, or produces less force. Introduce MASS word wall card to help with this. The goal is to guide the conversation so that the students have come to the conclusions that spherical objects roll more easily, higher ramps produce more speed, and heavier and faster objects produce bigger pushes.
Concluding Worksheet 15 minutes	Depending on lesson time, pass out the worksheet and work through it together. Or, you can do the worksheet at a later time within the next 2 days to review and reinforce the lesson.

Formative Assessment Discussion Questions

1) What does SPEED mean?

2) How can we change the SPEED of an object?

3) What actions make an object go FASTER?

4) What actions make an object go SLOWER?

5) Observe your group's object. What is it? What properties does it have?

6) Do you think it will be able to go down the ramp? Why or why not?

7) Will your object be able to **push** over the box? Why or why not?

8) At what speed will your object go down the ramp, slow, or fast? Why?

9) Look at our data table. What do the objects that could move down the ramp have in common?

10) Look at our data table. What do the objects that could push over the box have in common?

11) Look at our data table. What do the objects that moved down the ramp slower have in common? What about the objects that moved faster?

Formative Assessment Discussion Questions

1) How can we change the SPEED of an object? Speed is how something moves. How fast or slow it goes. Speed is the magnitude of an object's velocity, or rate of change of an object's position.

2) What actions make an object go FASTER? Objects with more energy go faster. A ramp can make something go faster. Giving something a strong push can make it move away from you faster.

3) What actions make an object go SLOWER? Objects that go slow have less energy than objects that move fast. It takes less energy to walk slowly than to run fast. Or say, walking through mud is slower than walking over a paved road.

4) Observe your group's object. What is it? What properties does it have? Example descriptions include round, long, pointy, rough, hard, light, heavy, etc.

5) Do you think it will be able to go down the ramp? Why or why not? ex: I think the marble can roll down the ramp because it is round and round objects can roll. Ex: I do not think the dice can go down the ramp because it is square shaped.

6) Will your object be able to **push** over the box? Why or why not? ex: I think the medium ball can push over the box because it is round and it feels heavy in my hand.

7) At what speed will your object go down the ramp, slow, or fast? Why? ex: I think the medium ball will go down fast because balls roll fast and it feels heavy. ex: I think the big foam ball will go down slow because sometimes big things are slow and it is not that heavy.

8) Look at our data table. What do the objects that could move down the ramp have in common? Most of the objects that easily moved down the ramps were round or spherical. Emphasize that other objects can move, but require a greater slope to do so. (For example, the rock or dice could not move until the slope of the ramp increased.)

9) Look at our data table. What do the objects that could push over the box have in common? Students should each two conclusions:
1) Heavier objects can give a stronger push
2) The higher the ramp, the faster each object moves, and faster objects can give a stronger push
Some students may say that "bigger" objects can push over the box. Help them to clarify the difference between BIG and HEAVY. The bigger foam ball is actually less

heavy (has less mass) than the medium ball, and therefore gives a weaker push, or produces less force than the heavier medium ball.

10) Look at our data table. What do the objects that moved down the ramp slower have in common? What about the objects that moved faster? Students should each a few conclusions:

1) Heavier objects moved down the ramps faster
2) The higher the ramp/steeper the slope, the faster each object moves
3) Round/Spherical objects moved faster than square or irregular shaped objects

Kindergarten Forces and Motion Lesson #2
Teacher Resource Page #2.b

	Did it move down the ramp?			Did it **push** over the box?			**Speed:** Very slow, Slow, Fast, Very Fast		
Object	Low 	Medium 	High 	Low 	Medium 	High 	Low 	Medium 	High 
Marble 									
Rock 									
Dice 									
Medium Ball 									
Pencil 									
Big Ball 									

Kindergarten Forces and Motion
Lesson #3 Engineering with pushes and pulls – Marbulous

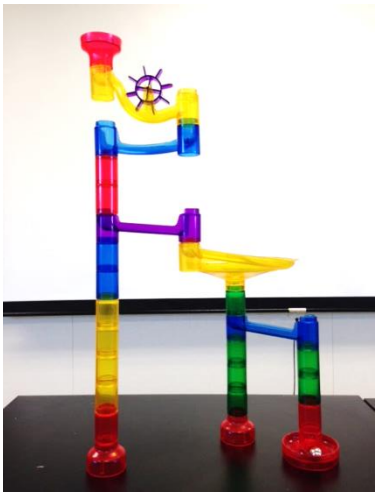
Objectives:

- To work as a team to build a self-standing Marbulous structure with one beginning and one end.
- To determine which Marbulous pieces change the direction and/or speed of the marble.

NGSS

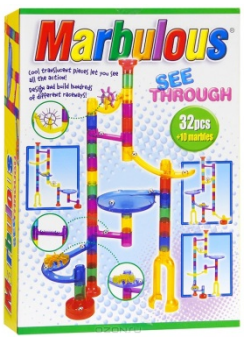
- **K-PS2-2:** Analyze data to determine if a design solution works as intended to change the speed of an object with a push or pull.*

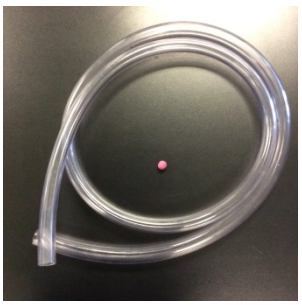
Teacher Background: The demo at the beginning of this lesson is from *Uncovering Student Ideas in Primary Science, Volume 1* by Page Keeley. Her explanation is "As the marble rolls down the marble tower's spiral track, a force toward the center of the spiral (centripetal force) caused by the outside wall of the track keeps the marble rolling in a spiral path. When the marble leaves the end of the track, it is no longer in contact with the walls of the track. Without the track pushing on it, the marble no longer has a center directed force acting on it that causes it to roll in a curved path. According to Newton's first law of motion, an object will remain at rest or in uniform motion unless acted on by an outside force. There is no longer a center-directed force exerted by the wall of the track pushing on the marble, so the marble rolls off the track and across the floor in a straight path. It will continue this way unless an outside force causes it to change direction or slow down and stop."



Materials & Teacher Setup: *use of the science lab recommended*

- Copies of student worksheet #3, one per student
    - Have one extra copy for yourself for the document camera. Have on display as students walk in.
- Lab tables and students arranged into 6 groups
- 7 Marbulous Sets *(they come with marbles – I would only give one marble to each group)*
    - One Marbulous set per table group.
    - Use 7th Marbulous set as your demo. Assemble into the structure shown to the right. (Also pictured on the back of the student worksheet.)
- Clear tubing
- Small Marble (or small ball of modeling clay)
- Word wall cards
- Teacher Resource Page #3a and #3b to project
- 2-3 Timers (can use iPads)
- 1-2 Parent Volunteers (to help with timing and to encourage teamwork)





Lesson Outline: 45-60 minutes

"Predict-Explain-Observe" **Intro Demo** 10 minutes	Pass out student worksheets. Explain the prompt on the front, then give 1-2 minutes for students to talk at their tables and make a **prediction**. Call on three students to **explain** what they think, always asking for their reason why. ("What makes you say that?") Show students that clear tubing can be used liked the spiral slide in the picture. Twist the tubing and place one end on a lab table. Ask students to **observe** what happens when a small marble is placed inside the tubing. As the marble shoots out of the bottom, it will go straight! Repeat the demo 1-2 times so that all students have a chance to see. Ask students to talk in groups for 1-2 minutes to revise their thinking. Call on student volunteers to explain why the marble goes straight, and help them arrive to the answer that once the marble is no longer held in by the **force** of the tubing walls, it will continue going in the direction when it left the tubing (straight.) Review **force** word wall card. 
Marbulous Intro 5-10 minutes	Ask students to flip over their papers, and show them the demo Marbulous structure you pre-built. Read-aloud the questions on the back side of the worksheet, and ask students to think about them as they observe the marble roll through the track. *(When does the marble go SLOWER? When does the marble go FASTER? When does the marble CHANGE DIRECTION?)* Think-pair-share which marbulous pieces speed up or slow down the marble. Roll the marble through the track one more time, then use the doc cam to draw arrows together. (See Key)
Marbulous Challenge Directions 5 minutes	Explain/read the following: 1) Each team must <u>work together</u> to build a marble tower with only <u>one end and one beginning</u>. 2) It must be able to stand on its own. (review word wall cards stable and unstable) 3) You want to build the tower where the marble rolls for the longest amount of time. 4) Your team has 20 minutes to build. 5) When you're ready to test, call over an adult and they will time your structure. Set one timer for 20 minutes and have a timer for yourself and your volunteers. Once teams are ready, say "Go!"
Marbulous Challenge 20 minutes	Allow students time to work. Encourage sharing and teamwork, and help students who need it, but don't build the tower for them. A common mistake is for students to put pieces upside down or facing the wrong direction. Help them to understand they must line up the holes for the marble to correctly roll through the track. Check the timer and

	periodically call out warnings. As groups finish and ask for testing, record their time on the board or on teacher resource page #3 under the doc cam. Teams can have their structures timed as many times as they want during the 20 minutes.
Conclusion 10 minutes	Once the 20 minutes is up, tell groups to stop. Use the conclusion questions on teacher resource page #3b to think-pair-share.

Kindergarten Force and Motion Lesson #3
Teacher Resource Page #3a

Team	Time (Seconds)

Kindergarten Force and Motion Lesson #3
Teacher Resource Page #3b

1) **What parts of this challenge were hardest for you and your team?**

2) **How did you keep your Marble tower from falling over? (How did you keep it stable and balanced?)**

3) **What helped make your marble go slower through the Marbulous tower?**

4) **What helped your team?**

Kindergarten Force and Motion Lesson #3
Teacher Resource Page #3b KEY/ Sample Student Answers

1. **What parts of this challenge were hardest for you and your team?**
   - **"Everyone tried to make their own tower it didn't work."** ***Respond about the importance of sharing ideas and working together.***
   - **"We ran out of time."** ***Engineers who build structures in real life must abide by deadlines. It takes practice to learn how to budget your time to finish projects before they are due.***

2. **How did you keep your Marble tower from falling over? (How did you keep it <u>stable</u> and <u>balanced</u>?)**
   - **Not put too many heavy pieces on top**
   - **Make sure you build legs for the tower for it to stand on**

3. **What helped make your marble go slower through the Marbulous tower?**
   - **The large round pieces make the marble go slower because they make the marble go in circles before dropping down.**
   - **Making the marble change directions makes it go slower.**
   - **Not having too many big drops makes the marble go slower**
   - **The piece with the spinning wheel makes the marble go slower because it loses speed pushing the wheel**

4. **What helped your team?**
   - **Working together and not fighting over the pieces**
   - **Testing the structure with the marble as we built it instead of waiting until the end (this is called prototyping)**
   - **Using as many pieces as possible made the marble take a longer amount of time**

Kindergarten Force and Motion
Lesson #4 Simple Machines

Objectives:

- To introduce students to basic simple machines and allow them to explore with how they move and work.
- To correctly identify the names of six simple machines.

NGSS:

- **K-PS2-1:** Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.
- **K-PS2-2:** Analyze data to determine if a design solution works as intended to change the speed of an object with a push or pull.*

Materials & Teacher Prep:

- GLAD Style Simple Machine Posters and Labels – put up onto whiteboard
    - Tape and/or magnets
- Box of wooden simple machines
- Rulers – one per pair
- Boxes of Crayon – two per pair
- One worksheet per student
- Pre-load BrainPop Jr Video: Simple Machines; projector

Lesson Sequence:

Intro 5 minutes	Show BrainPop Jr Video: Simple Machines
GLAD Vocab 10 minutes	Show students the pictures of each simple machine, and practice saying the name and read to them what each machine does. Put each poster onto whiteboard with a magnet. Pass out the name labels randomly to students. Then for each simple machine poster, read the definition and ask students who has the machine label that matches. For example: Ask, "Who has the machine that uses one or more grooved wheels connected by a rope, and is used to raise and lower objects?" Then the student with "pulley" should stand up and place the label onto the poster with tape or a magnet.
Lever 5 minutes	Give each pair of students a ruler and 2 boxes of crayons. Tell them to "Figure out a way to lift one box of crayons without touching them." Give them time to figure it out on their own before helping as needed. See pictures:   After most pairs have figured out how to solve the challenge, ask them "What type of simple machine did you make to lift the box of crayons?" They should

	respond with a level. Ask them how they knew they had made a lever. Sample answers include: "The ruler is a bar that raised the weight of the crayons." "Or it looked like a see-saw."
Explore Simple Machines 20 minutes	Tell students that they will have some time to explore with several different simple machines. Ask them to determine the following: 1) Is this a simple machine? What kind of simple machine do you think it is? 2) What does this machine do? 3) How do you think it works? *(you can write or project these onto the board/screen)* Place each simple machine in the center of a group table. Give students about 3 minutes at each station, and then allow them to rotate. Students should manipulate the different machines and discuss the questions.
Conclusion 5 minutes	After students have rotated through all stations, ask the focus questions again for each machine, but call on volunteers from the whole class. 1) Is this a simple machine? What kind of simple machine do you think it is? 2) What does this machine do? 3) How do you think it works? Lead them to the correct answers by reminding them of the different machines, reviewing the GLAD posters, and manipulating the machines
Review Worksheet 15 minutes *(do within 3 days of lesson)*	Provide each student with a simple machines worksheet, and time to do it on their own. Then review.

Extension Ideas:

Extension Video	Show Bill Nye the Science Guy Simple Machine Video!
Extension Centers	Allow students more time to explore with the simple machines as a center or during free time stations.