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Assessing with Learning Progressions in Science

FOSS LEVERS & PULLEYS

Instructional Tools | **Contributors: Linda Reichlin, Anjeannette Hammer, Caitlin Gregory and Laura Cross**

Northwest Educational Service District 189
Together We Can

Funding information:
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Instructional Tools

In this packet you will find a set of instructional supports for science materials. These documents represent the work-in-progress of teachers in the Assessing with Learning Progressions in Science Project, a Math Science Partnership through the Northwest Educational Service District in Washington State. While we encourage others to use the materials, please know the power of these tools lies in the collaborative discussion and analysis that occurs during their creation. We strongly suggest that anyone utilizing these tools make them your own, adjusting them to fit your teaching context and district priorities. Professional development tools to aid you in this process are available on the ALPS project web page www.nwesd.org/nwalps. For access to editable versions of these documents please contact Nancy Menard nmenard@nwesd.org.

Overview of the Tools (not every unit tool-set will include all of these tools)

Unit Overview

The unit overview grid lays out learning targets or important scientific ideas from Washington State Standards for each investigation in the module and clarifies the success criteria for each learning target. It also details the formative assessments that have been designed to assess each target in the investigation.

Learning Progressions

A learning progression is a graphical representation of the path students take toward mastery of a science "big idea". The ALPS *Learning Progression* documents include a description of an important big idea from the *Washington State Science Learning Standards* and the progression of building-block learning targets that students master on their way toward an understanding of that big idea. For each building-block learning target the student success criteria is identified and one or more formative assessment tasks to elicit evidence of student understanding are suggested.

Formative Assessment Tasks

The suggested formative assessment tasks are examples of tools used by the teachers in the ALPS project to gather evidence of student understanding. The *Assessment Task Cover Sheet* details each assessment and gives administration tips and suggestions for instructional adjustments based on some of the common student struggles they encountered.

Student Work Samples

Selected student work samples from students in ALPS classrooms give a picture of the range of student responses gathered from sample formative assessments. The *Student Work Sample Cover Sheet* describes the student work samples and the teacher's interpretation of student understanding.

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Levers & Pulleys Unit Plan with Formative Assessment (NW ALPS)

Lesson		Learning Targets & Success Criteria	Assessment	Vocabulary	Materials
Pre-Teaching					
Pre-teach Force	Force	There's always a force involved in any change of motion, speed or direction. ✓ I can identify the forces required for a change in motion, speed or direction.	In pairs, draw a speed-time graph showing what happens when you kick a soccer ball. Label the part of your graph where your foot is in contact with the ball and label where force is acting on the ball.	o Force	o Whiteboards o Dry-erase markers o Erasers o Safari video: Real World Science – Force o Web: Push Car Simulator
Investigation 1: Levers					
1-1 Introduction to Levers *Simple Machines*	Systems	Mechanical systems change forces and motions. ✓ I can show how forces and motion are changed by a simple machine.	Step 6: Walk around and ask students to identify the fulcrum and show where to put their finger to make the load easier to lift and harder to lift.	o Lever o Lever Arm o Fulcrum o Load o Effort o Newtons	o Spring scales w/ rubber bands o Loads w/ rubber bands o Half-meter sticks o Binder clips o Dowels o Pencil-top erasers o Duct tape
	Systems	Mechanical systems like levers use fulcrums to make effort easier where the effort is the input and the load is the output. ✓ I can diagram a lever that includes a load, fulcrum and effort and makes effort easier or harder.	Step 8: Draw two pictures of lever systems. In the first, show where on the lever you press in order to use the least amount of force. In the second, show where you press in order to use the most amount of force. Label the load and effort in each picture.		
	Inquiry	Questions and hypotheses should drive the investigation. ✓ Given a question, I can write a hypothesis.	Write the question in front of the class. Students record hypotheses on post-its, pair & share with a neighbor and stick them up in front of the class.		

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Math Science Partnership
File Name: LP_overview

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Lesson		Learning Targets & Success Criteria	Assessment	Vocabulary	Materials
1-2 Lever Experiment A *Class-1 Levers*	Force	An object that is not moving has balanced forces. Unbalanced forces will cause changes in the speed or direction of an object's motion. ✓ In a simple machine, I can identify the forces that are balanced when the machine isn't moving. I can identify the unbalanced forces involved in a change of motion.	Use the data from the graph (Student Sheet 4) to answer: "What is the relationship between the load and the effort in a lever system?"	o Two-coordinate graphs o Advantage	o Student Sheet 4 o Student Sheet 5 o See 1-1
	Systems	We can predict how much easier a load will be based on the geometry of the system. ✓ I can explain how types of mechanical systems will affect the amount of effort required.	Response Sheet – Levers (Student Sheet 5): Students decide which lever will provide the greatest advantage and explain why.		
1-3 Lever Experiment B *The Wheel and Axle*	Force	An object that is not moving has balanced forces. Unbalanced forces will cause changes in the speed or direction of an object's motion. ✓ In a simple machine, I can identify the forces that are balanced when the machine isn't moving. I can identify the unbalanced forces involved in a change of motion.	Use the data from the graph (Student Sheet 6) to answer: "What is the relationship between the load and the effort in a lever system?"		o Student Sheet 6 o See 1-1
	Inquiry	A valid investigation has one manipulated (independent) variable while other variables are controlled (dependent). ✓ I can identify the controlled and manipulated variables in my investigation.	Before doing the experiment, write down which variables will be controlled and which variable will be manipulated.		
Investigation 2: More Leverage					
2-1 Lever Classes	Inquiry	Scientific reports and investigations should be replicable and clearly communicate findings and how variables were affected. ✓ Given an outline, I can use a systematic approach to record and communicate data so that my experiment can be replicated.	Students complete the investigation outline and draw diagrams of the lever systems they discover in their notebooks. Students trade outlines with a partner to replicate the lever systems described.	o Class-1 levers o Class-2 levers o Class-3 levers	o See 1-1

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Lesson	Learning Targets & Success Criteria		Assessment	Vocabulary	Materials
2-2 Lever Diagrams *Class-2 Levers*				o Diagram	o Student Sheet 10 o Student Sheet 11 o See 1-1
2-3 Real-World Levers *Class-3 Levers*				o	o Student Sheet 12 o Broom o Nutcracker o Scissors o Bottle Opener o Pliers o Tweezers o Hammer o Lever diagram posters o Lever picture posters
2-4 Lever Pictures *The Inclined Plane*				o	o Student Sheets 16-17
Investigation 3: Pulleys					
3-1 One-Pulley Systems *Pulleys*	**Systems**	Mechanical systems like pulleys use wheels and ropes to make effort easier where the effort is the input and the load is the output. ✓ I can diagram a pulley that includes a load, rope, wheel and effort and makes effort easier.	Step 9: Student Sheet 18 Students diagram four types of pulley systems and describe how the type of pulley changes the advantage. With 3-1, diagram the single-fixed and single-movable pulleys. Continue during 3-2, step 6 with double pulleys.	o Pulley o Fixed pulley o Movable pulley o Mechanical advantage o Directional	o Student Sheet 18 o Half-meter sticks o Binder clips o Spring scales w/ paper clip o Loads w/ rubber

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Lesson	Learning Targets & Success Criteria		Assessment	Vocabulary	Materials
	Systems	🎯 We can predict how much easier a load will be based on the geometry of the system. ✓ I can explain how types of mechanical systems will affect the amount of effort required.	Response Sheet – Pulleys (Student Sheet 19): Students describe a pulley system that will reduce the effort required in a given scenario.	advantage	band o Single pulleys o Ropes o Heavy books o Duct tape o Student Sheet 19
3-2 Two-Pulley Systems *Dear Boss*	Inquiry	🎯 A conclusion needs to be tied to the question and hypothesis and supported by the data gathered. ✓ I can generate a scientific conclusion to a specific question based on the data gathered.	Inv. 3-2 Step 9: Students record conclusions on investigation outline. Students pair-share and give each other feedback on what they should add to make a more complete conclusion. Teacher walks the room and listens in on conversations.	o Simple machine	o See 3-1
3-3 Pulley Game *The Wedge*	Force	🎯 Changing the load, position or effort in a machine will change the advantage. ✓ I can move the load, position or effort to change the advantage in a simple machine.	Math Extension (Student Sheet 30): Students will demonstrate that the advantage can be changed by changing the type of pulley used in the system.	o	o Student Sheet 30 o See 3-1
Investigation 4: Pulleys at Work					
4-1 Effort in Pulley Systems *The Work of Pulleys*				o	o Student Sheet 20 o See 3-1 o Pulley system posters
4-2 Measuring Distance *The Screw*	Force	🎯 Advantage is a gain in effort, distance or change of direction ✓ In a simple machine, I can predict the advantage or gain in effort, distance or change of direction for different unbalanced forces.	Student Sheet 24: Students predict the advantage and disadvantage of a pulley system in a given scenario.	o	o Student Sheet 23 o Student Sheet 24 o See 3-1 o Cardboard sheets o White paper

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Lesson	Learning Targets & Success Criteria	Assessment	Vocabulary	Materials
4-3 Choosing Your Own Investigation *Thank You, Mr. Clumpet*			o	o

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Learning Progression

FOSS Levers & Pulleys: Force

Prerequisite skills:

The relative strength of two forces can be compared by observing the difference in how they move a common object (2-3 PS1D)

Motion can be described as a change in position over a period of time (2-3 PS1A)

There is always a force involved when something starts moving or changes its speed or direction of motion (2-3 PS1B)

Learning Target 1:

There's always a force involved in any change of motion, speed or direction.
(2-3 PS1B)
Prior to Inv. 1

Success Criteria:
I can identify the forces required for a change in motion, speed or direction.

Formative Assessment:
In pairs, draw a speed-time graph showing what happens when you kick a soccer ball. Label the part of your graph where your foot is in contact with the ball and label where force is acting on the ball.

Learning Target 2:

An object that is not moving has balanced forces. Unbalanced forces will cause changes in the speed or direction of an object's motion.
(6-8 PS1C)
Inv. 1, Parts 2 and 3

Success Criteria:
In a simple machine, I can identify the forces that are balanced when the machine isn't moving. I can identify the unbalanced forces involved in a change of motion.

Formative Assessment:
Inv. 1-2, 1-3 (Student Sheets 4 & 6) Lever experiment A & B - Use the data from the graphs to answer: "What is the relationship between the load and the effort in a lever system?"

Learning Target 3:

Advantage is a gain in effort, distance or change of direction.

Inv. 4, Part 2

Success Criteria:
In a simple machine, I can predict the advantage or gain in effort, distance or change of direction for different unbalanced forces.

Formative Assessment:
Inv. 4-2 (Student Sheet 24) Students predict the advantage and disadvantage of a pulley system in a given scenario.

Learning Target 4:

Changing the load, position or effort in a machine will change the advantage.
(6-8 PS1C)
Inv. 3, Part 3

Success Criteria:
I can move the load, position or effort to change the advantage in a simple machine.

Formative Assessment:
Inv. 3-3 Math Extension (Student Sheet 30)

Students will demonstrate that the advantage can be changed by changing the type of pulley used in the system.

Big Idea:

Machines can change the forces or directions necessary to move an object.
(6-8 PS1C)

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Big Idea: Machines can change the forces or directions necessary to move an object. (6-8 PS1C)

Formative Assessment Task Cover Sheet

Learning Target 1	
Assessment Task Details	**Teacher Background**
Brief Description of the Assessment Task: In pairs, draw a speed-time graph showing what happens when you kick a soccer ball. Label the part of your graph where your foot is in contact with the ball and label where force is acting on the ball.	**Administration Tips:** Bring a soccer ball to demonstrate. Many students tried to graph a ball traveling through the air, make sure they know it is being kicked on the ground and they should be graphing the speed of the ball. **Suggestions for Instructional Adjustments:** Use the web resource (included in teacher instructions) after they have made their graphs to reinforce the idea that speed will only increase when force is applied. To give students another opportunity for success, consider asking them to graph a similar scenario such as a club hitting a golf ball.
Learning Target: There's always a force involved in any change of motion, speed or direction. (2-3 PS1B) Prior to Inv. 1	
Success Criteria: I can identify the forces required for a change in motion, speed or direction.	
Student Task Sheet Included: no Teacher Instructions Included: yes Student Work Samples Included: yes	

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Big Idea: Machines can change the forces or directions necessary to move an object. (6-8 PS1C)

Learning Target 2	
Assessment Task Details	**Teacher Background**
Brief Description of the Assessment Task: Inv. 1-2, 1-3 (Student Sheets 4 & 6) Lever experiment A & B - Use the data from the graphs to answer: "What is the relationship between the load and the effort in a lever system?"	**Administration Tips:** **Suggestions for Instructional Adjustments:** Depending on your students' experience level with graphing, it may help to scaffold the instruction by setting up the graph scales with them and plotting some sample points.
Learning Target: An object that is not moving has balanced forces. Unbalanced forces will cause changes in the speed or direction of an object's motion. (6-8 PS1C) Inv. 1, Parts 2 and 3	
Success Criteria: In a simple machine, I can identify the forces that are balanced when the machine isn't moving. I can identify the unbalanced forces involved in a change of motion.	
Student Task Sheet Included: no Student Work Samples Included: no	

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Big Idea: Machines can change the forces or directions necessary to move an object. (6-8 PS1C)

Learning Target 3, Assessment Task Letter	
Assessment Task Details	**Teacher Background**
Brief Description of the Assessment Task: Inv. 4-2 (Student Sheet 24) Students predict the advantage and disadvantage of a pulley system in a given scenario.	**Administration Tips:** Encourage students to count the ropes and highlight the information about how Belinda can *only* lift one crate. **Suggestions for Instructional Adjustments:** Consider separating the two questions if your students often don't answer all questions completely.
Learning Target: Advantage is a gain in effort, distance or change of direction. Inv. 4, Part 2	
Success Criteria: In a simple machine, I can predict the advantage or gain in effort, distance or change of direction for different unbalanced forces.	
Student Task Sheet Included: no Student Work Samples Included: no	

Learning Target 4	
Assessment Task Details	**Teacher Background**
Brief Description of the Assessment Task: Inv. 3-3 Math Extension (Student Sheet 30) Students will demonstrate that the advantage can be changed by changing the type of pulley used in the system.	**Administration Tips:** Have the students create a systematic way of showing their answer. **Suggestions for Instructional Adjustments:** Do this assignment in two parts. First, have the students work on getting everyone to the top of the cliff. Second, have them figure out the fewest number of lifts. A suggestion to take this learning further would be to set up a pulley system in your gym. Have students be the load by sitting on a mat and other students be the effort by pulling the rope to drag the mat along the floor. Revise the pulley system to make the load easier to pull. When using multiple pulleys, it becomes very clear to students how far they have to pull the ropes.
Learning Target: Changing the load, position or effort in a machine will change the advantage. (6-8 PS1C) Inv. 3, Part 3	
Success Criteria: I can move the load, position or effort to change the advantage in a simple machine.	
Student Task Sheet Included: no Student Work Samples Included: no	

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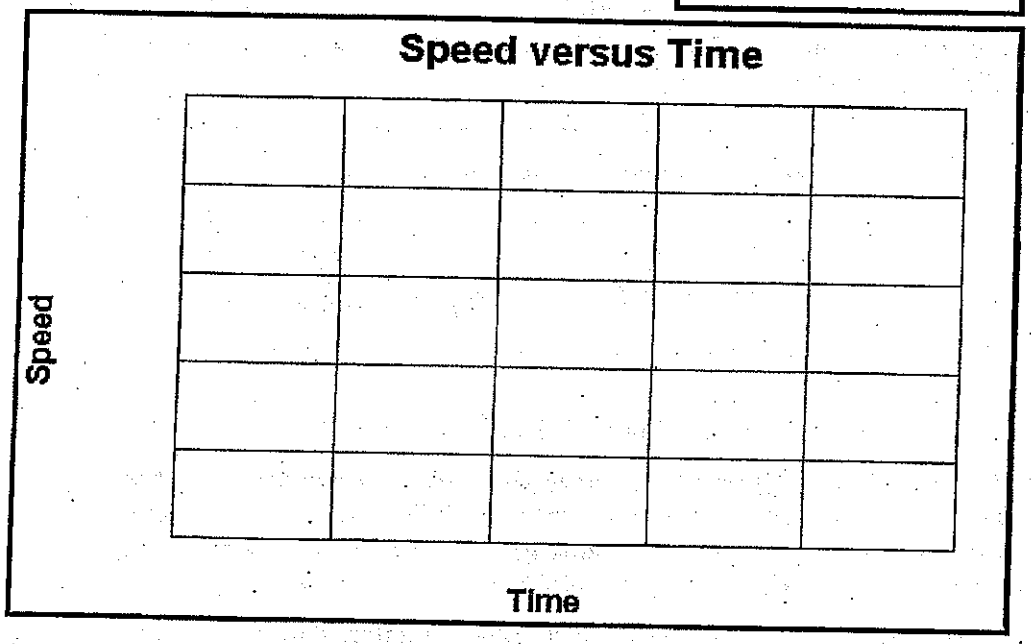
Initial Ideas

Think about a soccer player kicking a stationary ball. As he interacts with it, by kicking it, the ball starts to move. After the kick, the ball rolls across the grass and gradually comes to a halt.

Sketch a speed-time graph for the motion of the ball. Be sure to include both the motion of the ball while the player's foot is touching it, and its motion after the foot has lost contact with it.



Using a colored pencil, indicate the period on the graph during which you think the foot was in contact with the ball and briefly explain your reasoning.

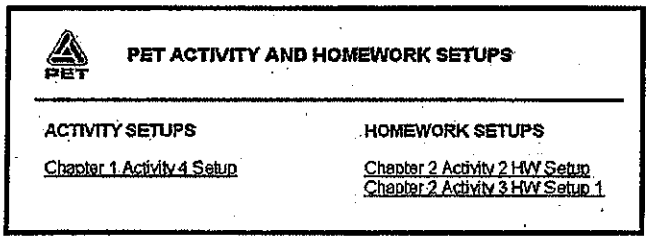
Using a different-colored pencil, indicate the period on the graph during which you think there was a force pushing the ball forward. Again, explain your reasoning.

Important: *See the notes at the end of this appendix regarding compatible operating systems and browsers.*

Use a computer connected to the Internet. After starting up your web browser you can access the simulators at:

http://cpucips.sdsu.edu/petsims

(You should check with your instructor to determine if the *url* for the simulator has changed.) When you go to this page you will see two lists of links, one for the simulator setups for in-class activities, the other for setups to be used in homework assignments. (The top of the page and the first few links should be similar to those shown below.)



To access one of these setups simply click on the relevant link.

Note that, depending on the speed of your Internet connection, it may take up to several minutes for the setup to fully load. Do not attempt to use your computer until the loading process is complete or it may interrupt the download and you will have to start all over again!

Once the setup is fully loaded you can run the simulator. The simulators are Java applets; on some of the latest versions of web browsers, you may need to click once on the simulator to activate the Java program.

Why do you think the ball gradually slows down and eventually stops after it has been kicked?

Now draw two pictures of the ball and use arrows to show what **forces** (if any) you think are acting on the ball at two different times during its motion. Label your arrows to show where the forces come from.

i) During the time foot was in contact with the ball.

ii) After the foot has lost contact and the ball is rolling across the grass.

Briefly explain the reasoning behind your pictures.

Discuss your ideas with your team and try to agree on what the speed-time graph and 'force' picture(s) should look like. Sketch your team's graph and picture(s) on a large presentation board.

Participate in a whole-class discussion about these questions. Make a note of any ideas or reasoning that are different from those of your team.

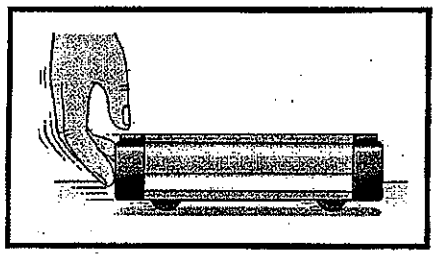
Collecting and Interpreting Evidence

EXPERIMENT: Is the motion of the cart after it has been pushed the same as during the push?

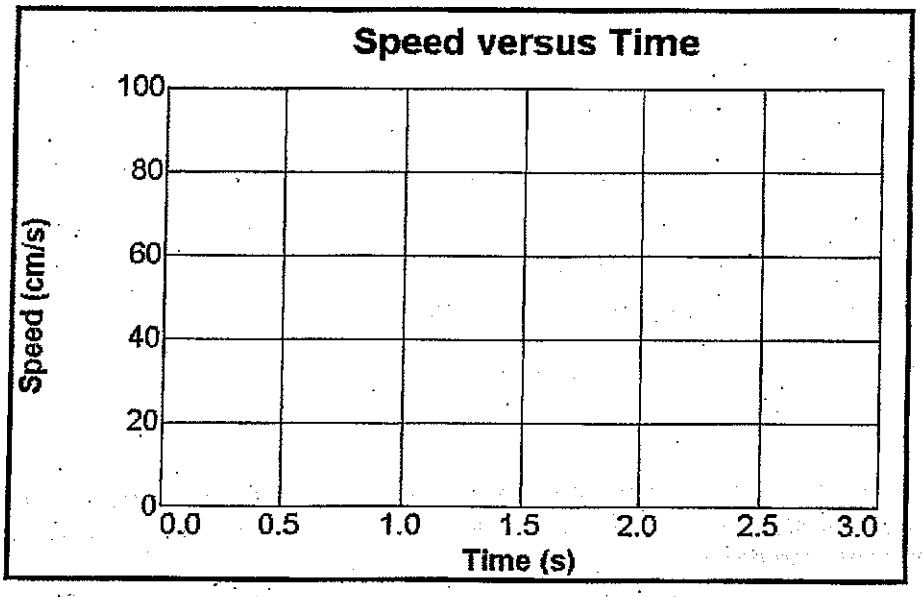
YOU WILL NEED:

- Low-friction cart
- Track
- Access to a Motion Sensor connected to a computer
- Access to the *I&M Computer Simulator*

STEP 1: Open the Motion Sensor data collection file for this experiment. Place your cart at rest on the track about 20-30 cm in front of the Motion Sensor. Start collecting Motion Sensor data and then have one of your team give the cart a quick push away from the sensor. (Stop the cart when it reaches the other end of the track.)



Sketch the speed-time graph for the motion of the cart.



What happens to the speed of the cart while the hand is actually in contact with it? Does it speed up quickly, slow down quickly, or move at a reasonably constant speed?

LEVERS & PULLEYS

Big Idea: Machines can change the forces or directions necessary to move an object. (6-8 PS1C)

Target 1, Assessment: *Speed/Time Graphs*

Formative Assessment Student Work Cover Sheet

Student Work Description

Sample 1: These students seemed to be showing the arc of the ball travelling through the air rather than the speed of the ball as evidenced by the fact that the ball's speed decreases as the graph continues to climb. The speed of the ball in this graph continues to increase after the foot has lost contact.

Sample 2: This group of students had some differing ideas. They also seemed to think that their graph was supposed to show the ball travelling through the air. The lowest line seems to show that the student understood that the ball would be fastest immediately after the kick and then slow down. The other two lines show an increase in speed after the ball was kicked.

Sample 3: This student did not seem to understand how to draw a graph. It also shows that the student did not understand the relationship between speed and force.

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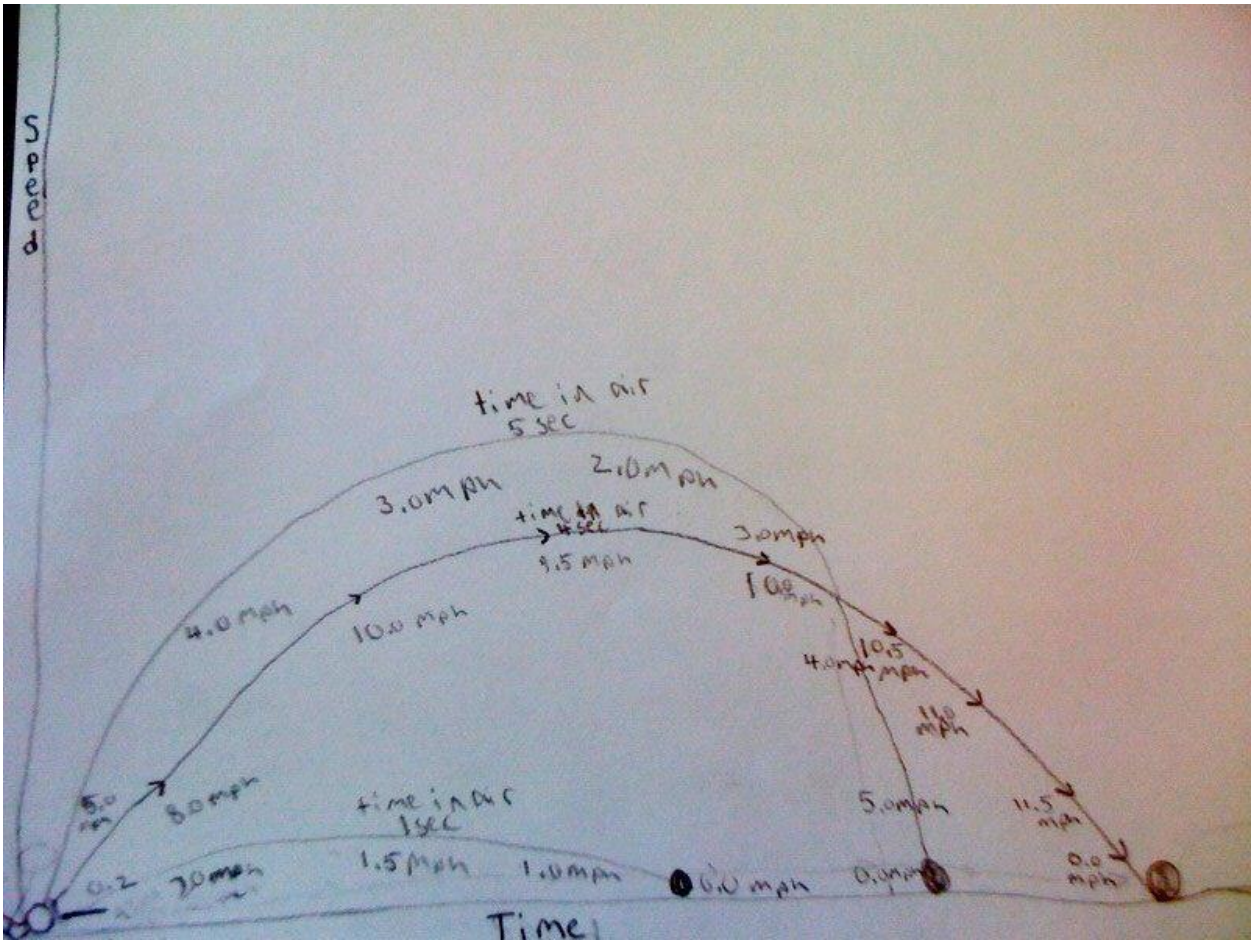
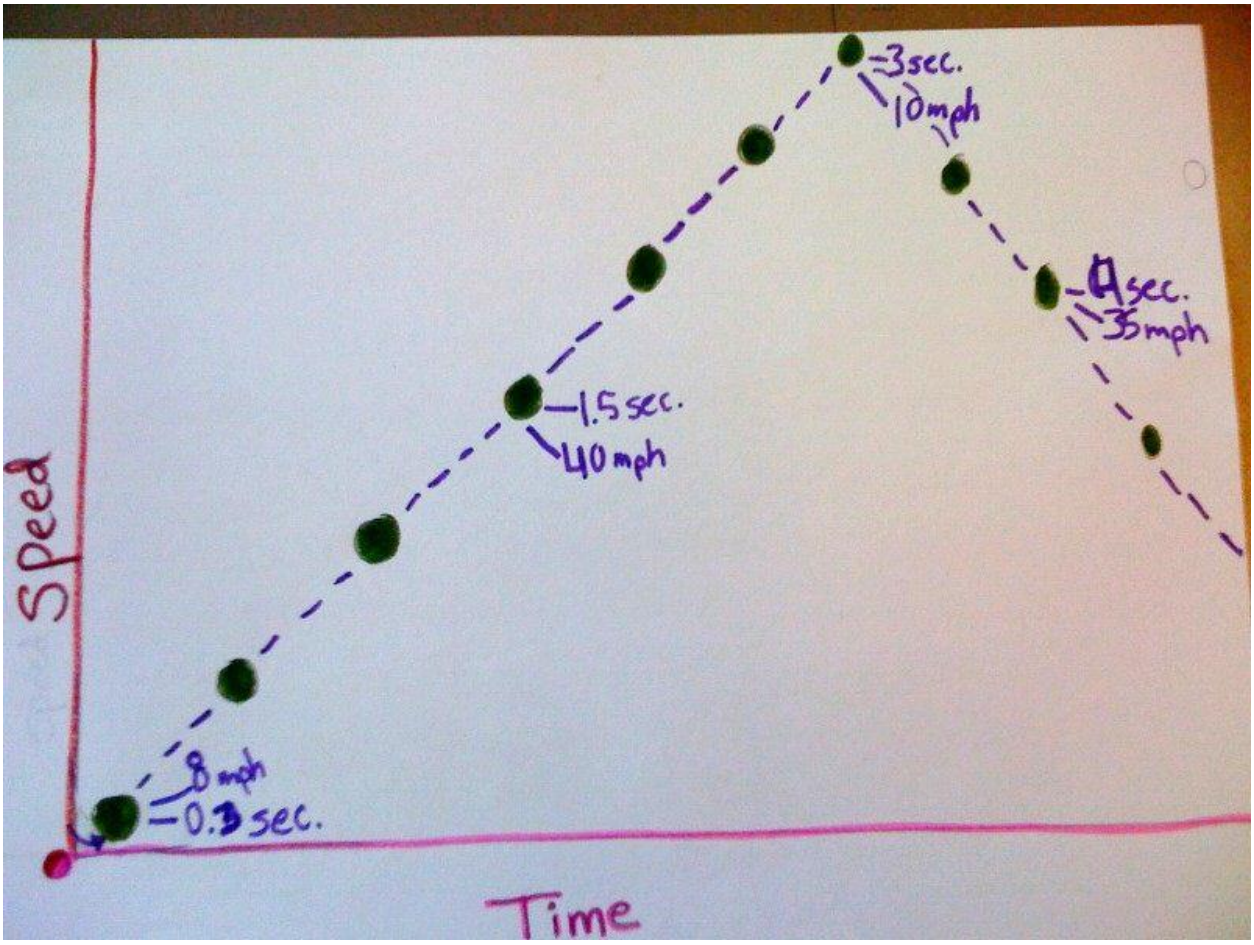
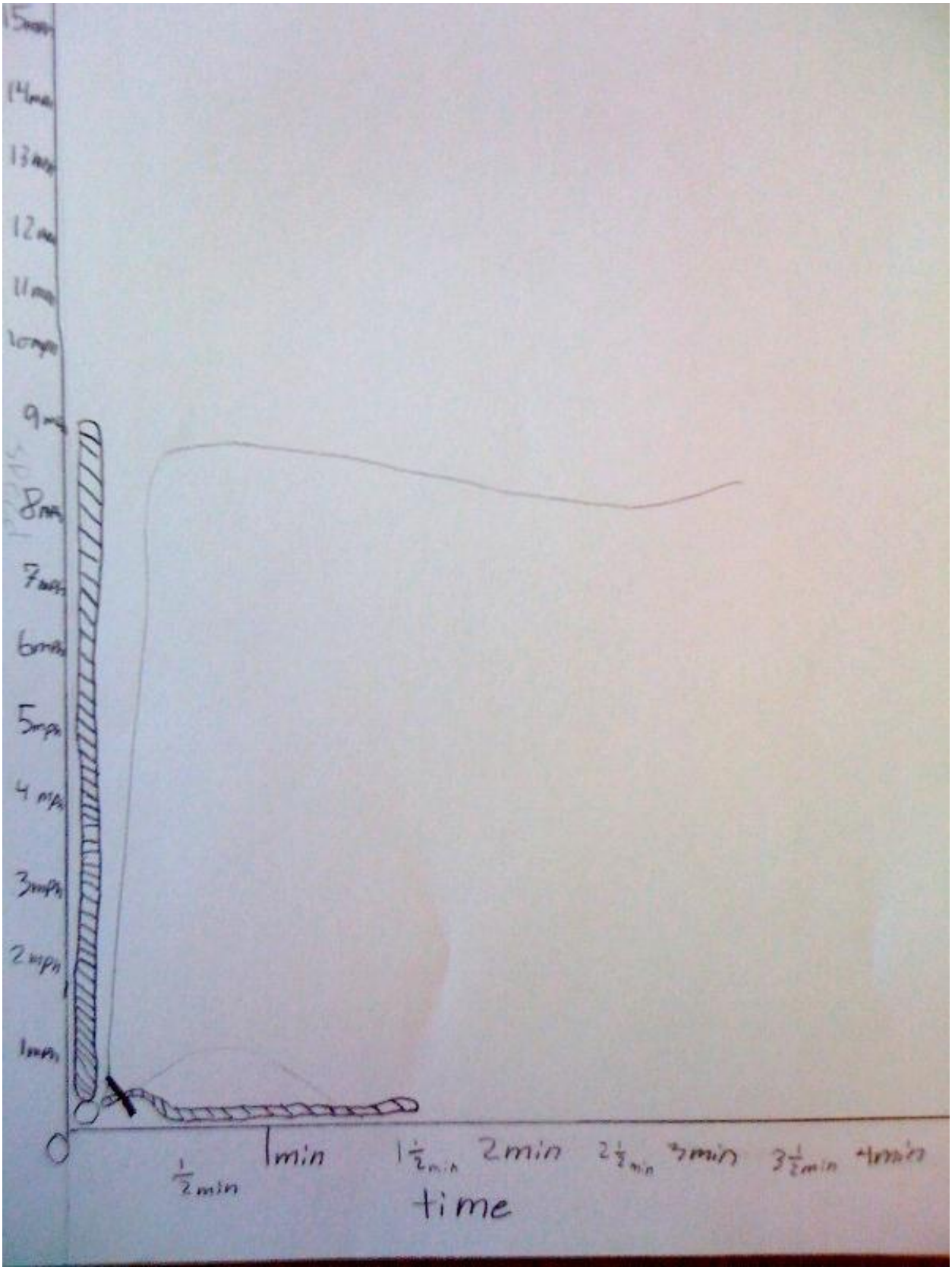

Speed
time in air
5 sec
3.0 mph
2.0 mph
4.0 mph
10.0 mph
9.5 mph
3.0mph
10.5 mph
11.0 mph
5.0 mph
8.0mph
time in air
1sec
1.5 mph
1.0mph
0.0 mph
11.5 mph
0.0 mph
Time

Sample 1



Sample 2



Sample 3

Learning Progression: Inquiry

Materials: FOSS Levers & Pulleys **Grade level: 5-6**

Prerequisite skill:

There are different variables that affect our investigations. (6-8 INQD)

Learning Target: **1**

Questions and hypotheses should drive the investigation.
(4-5 INQA-B, 6-8 INQA-B)
Inv. 1, Part 1

Success Criteria:
Given a question, I can write a hypothesis.

Formative Assessment:
Inv. 1-1: Write the question in front of the class. Students record hypotheses on post-its, pair & share with a neighbor and stick them up in front of the class.

On-going: Student-generated hypotheses for individual investigations

Learning Target: **2**

Scientific reports and investigations should be replicable and clearly communicate findings and how variables were affected.
(4-5 INQD, 6-8 INQC & G)
Inv. 2, Part 1

Success Criteria:
Given an outline, I can use a systematic approach to record and communicate data so that my experiment can be replicated.

Formative Assessment:
Inv. 2-1: Students complete the investigation outline and draw diagrams of the lever systems they discover in their notebooks. Students trade outlines with a partner to replicate the lever systems described.

Learning Target: **3**

A valid investigation has one manipulated (independent) variable while other variables are controlled (dependent).
(6-8 INQD)
Inv. 1, Part 3

Success Criteria:
I can identify the controlled and manipulated variables in my investigation.

Formative Assessment:
Inv. 1-3: Before doing the experiment, write down which variables will be controlled and which variable will be manipulated.

Learning Target: **4**

A conclusion needs to be tied to the question and hypothesis and supported by the data gathered.
(4-5 INQG, 6-8 INQF)
Inv. 3, Part 2

Success Criteria:
I can generate a scientific conclusion to a specific question based on the data gathered.

Formative Assessment:
Inv. 3-2 Step 9: Students record conclusions on investigation outline. Students pair-share and give each other feedback on what they should add to make a more complete conclusion. Teacher walks the room and listens in on conversations.

Big Idea:

Valid experiments and investigations have specific criteria: asking questions, data collection, analysis and reporting. (4-5 INQA-H, 6-8 INQA-G)

Later big ideas that build on this big idea include:

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Math Science Partnership
File Name: LP_Inquiry

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Big Idea: Valid experiments and investigations have specific criteria: asking questions, data collection, analysis and reporting. (4-5 INQA-H, 6-8 INQA-G)

Formative Assessment Task Cover Sheet

Learning Target 1

Assessment Task Details	Teacher Background
Brief Description of the Assessment Task: Inv. 1-1: Write the question in front of the class. Students record hypotheses on post-its, pair & share with a neighbor and stick them up in front of the class.	**Administration Tips:** Use the sentence stem "If…then…because…" to help students write a complete hypothesis. **Suggestions for Instructional Adjustments:** Any feedback should be directed towards writing a complete hypothesis rather than the correctness of student thinking.
Learning Target: Questions and hypotheses should drive the investigation. (4-5 INQA-B, 6-8 INQA-B) Inv. 1, Part 1	
Success Criteria: Given a question, I can write a hypothesis.	
Student Task Sheet Included: no Student Work Samples Included: yes	

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Big Idea: Valid experiments and investigations have specific criteria: asking questions, data collection, analysis and reporting. (4-5 INQA-H, 6-8 INQA-G)

Learning Target 2	
Assessment Task Details	**Teacher Background**
Brief Description of the Assessment Task: Inv. 2-1: Students complete the investigation outline and draw diagrams of the lever systems they discover in their notebooks. Students trade outlines with a partner to replicate the lever systems described.	**Administration Tips:** **Suggestions for Instructional Adjustments:** After students have attempted to replicate lever systems, discuss what information was missing from the diagrams and try again.
Learning Target: Scientific reports and investigations should be replicable and clearly communicate findings and how variables were affected. (4-5 INQD, 6-8 INQC & G) Inv. 2, Part 1	
Success Criteria: Given an outline, I can use a systematic approach to record and communicate data so that my experiment can be replicated.	
Student Task Sheet Included: yes Student Work Samples Included: no	

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Big Idea: Valid experiments and investigations have specific criteria: asking questions, data collection, analysis and reporting. (4-5 INQA-H, 6-8 INQA-G)

Learning Target 3	
Assessment Task Details	**Teacher Background**
Brief Description of the Assessment Task: Inv. 1-3: Before doing the experiment, write down which variables will be controlled and which variable will be manipulated.	**Administration Tips:** **Suggestions for Instructional Adjustments:** Review the vocabulary (controlled and manipulated variables). Make sure that students understand that only one thing should be changed while everything else stays the same.
Learning Target: A valid investigation has one manipulated (independent) variable while other variables are controlled (dependent). (6-8 INQD) Inv. 1, Part 3	
Success Criteria: I can identify the controlled and manipulated variables in my investigation.	
Student Task Sheet Included: no Student Work Samples Included: no	

Learning Target 4	
Assessment Task Details	**Teacher Background**
Brief Description of the Assessment Task: Inv. 3-2 Step 9: Students record conclusions on investigation outline. Students pair-share and give each other feedback on what they should add to make a more complete conclusion. Teacher walks the room and listens in on conversations.	**Administration Tips:** Be sure to emphasize the inclusion of evidence, data and/or diagrams in the conclusion. **Suggestions for Instructional Adjustments:** When providing feedback, ask students a question that will cause them to think more deeply about what they could add to their conclusions.
Learning Target: A conclusion needs to be tied to the question and hypothesis and supported by the data gathered. (4-5 INQG, 6-8 INQF) Inv. 3, Part 2	
Success Criteria: I can generate a scientific conclusion to a specific question based on the data gathered.	
Student Task Sheet Included: yes Student Work Samples Included: no	

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LEVERS & PULLEYS

Big Idea: Valid experiments and investigations have specific criteria: asking questions, data collection, analysis and reporting. (4-5 INQA-H, 6-8 INQA-G)

Target 1, Assessment: Hypothesis

Formative Assessment Student Work Cover Sheet

Student Work Description

Sample 1: The first student used the "If…then…because…" structure. The second used "If…because…" and the third did not use the structure and was unclear about what they were describing.

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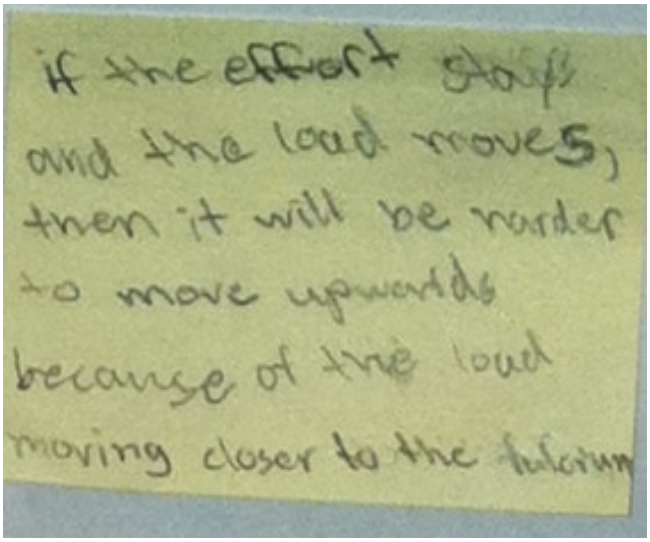
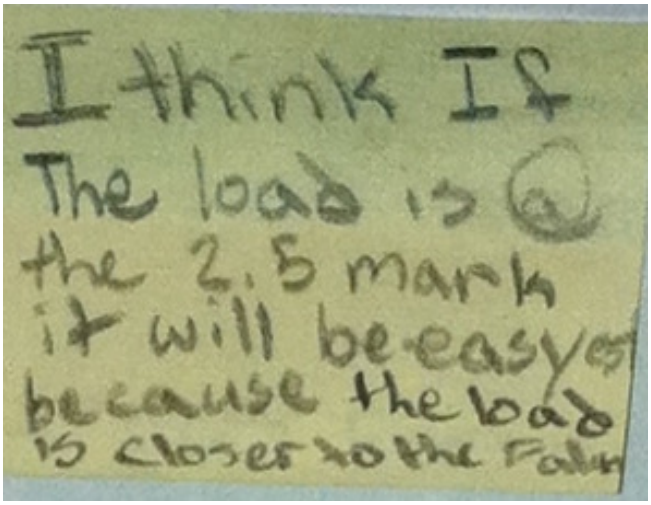
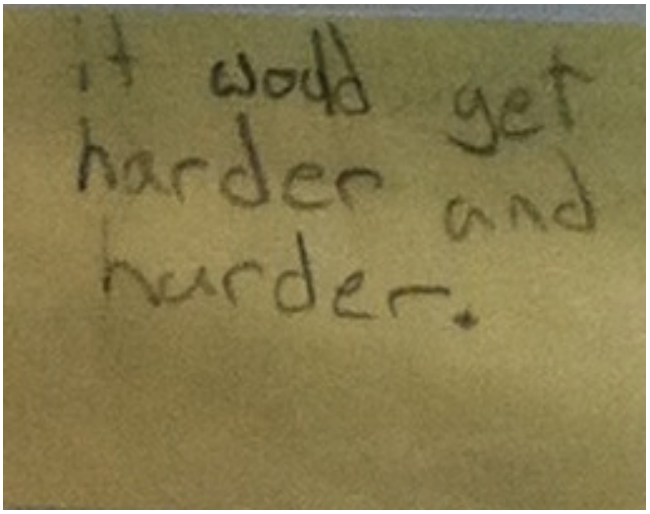

if the effort stays
and the load moves,
then it will be harder
to move upwards
because of the load
moving closer to the fulcrum


I think If
The load is @
the 2.5 mark
it will be easyer
because the load
is closer to the Fulc


it wodd get
harder and
harder.

Levers & Pulleys 2.1: Lever Classes

QUESTION: Is there any advantage to moving the fulcrum to new locations along the lever arm?

PREDICTION/HYPOTHESIS:

If _____ then_____

because_____.

MATERIALS: 1 spring scale with rubber band, 1 load with rubber band, 1 modified half-meter stick, 1 binder clip, 1 dowel, 1 pencil-cap eraser, masking tape, heavy textbook

EXPERIMENT

Controlled Variable: _____Manipulated Variable: _____

EXPERIMENT

Procedure:

1. Set up a lever system (see 1.1 for instructions)
2. Attempt different arrangements of the load, effort, and fulcrum to see if any provide an advantage.

OBSERVATIONS: Draw diagrams of your new lever systems in your notebook.

ANALYSIS (What does your data tell you?)

Summary: I discovered that_____

_____

_____

_____

_____

CONCLUSION (Answer the original question and explain whether or not your hypothesis was correct)

_____

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Levers & Pulleys 3.2: Two-Pulley Systems

QUESTION: *What is the advantage (if any) to using two pulleys at the same time?*

PREDICTION/HYPOTHESIS:

If _____*then*_____

*because*_____.

MATERIALS: *1 half-meter stick, 1 binder clip, 1 spring scale with paper clip, 1 load with rubber band, 2 single pulleys, 1 75cm rope, 1 heavy textbook, duct tape*

EXPERIMENT

Controlled Variable: _____***Manipulated Variable***: _____

EXPERIMENT

Procedure:

1. *Set up a pulley system (see instructions on 3.1)*
2. *Use the pulleys, rope and load to create a two-pulley system*

OBSERVATIONS: *Draw diagrams of your pulley systems on Student Sheet #18.*

ANALYSIS (What does your data tell you?)

Summary: *I discovered that*_____

_____

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CONCLUSION (Answer the original question and explain whether or not your hypothesis was correct)

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Learning Progression: Systems

Materials: FOSS Levers & Pulleys **Grade level: 5-6**

Prerequisite skill: Understand the difference between mechanical and non-mechanical systems.

Learning Target: **1**

Mechanical systems change forces and motions.

Inv. 1, Part 1

Success Criteria:
I can show how forces and motion are changed by a simple machine.

Formative Assessment:
Inv. 1-1 Step 6: Walk around and ask students to identify the fulcrum and show where to put their finger to make the load easier to lift and harder to lift.

Learning Target: **2**

Mechanical systems like levers use fulcrums to make effort easier where the effort is the input and the load is the output.
(4-5 SYSC)
Inv. 1, Part 1

Success Criteria:
I can diagram a lever that includes a load, fulcrum and effort and makes effort easier or harder.

Formative Assessment:
Inv. 1-1 Step 8: Draw two pictures of lever systems. In the first, show where on your lever you press in order to use the least amount of force. In the second, show where you press in order to use the most amount of force. Label the load and effort in each picture.

Learning Target: **3**

Mechanical systems like pulleys use wheels and ropes to make effort easier where the effort is the input and the load is the output.
(4-5 SYSC)
Inv. 3, Part 1

Success Criteria:
I can diagram a pulley that includes a load, rope, wheel and effort and makes effort easier.

Formative Assessment:
Inv. 3-1 Step 9: Student Sheet 18
Students diagram four types of pulley systems and describe how the type of pulley changes the advantage. With 3-1, diagram the single-fixed and single-movable pulleys. Continue during 3-2, step 6 with double pulleys.

Learning Target: **4**
We can predict how much easier a load will be based on the geometry of the system.

Inv. 1, Part 2
Inv. 3, Part 1

Success Criteria:
I can explain how types of mechanical systems will affect the amount of effort required.

Formative Assessment:
a) Inv. 1-2 Response Sheet – Levers (Student Sheet 5)
Students decide which lever will provide the greatest advantage and explain why.

b) Inv. 3-1 Response Sheet – Pulleys (Student Sheet 19)
Students describe a pulley system that will reduce the effort required in a given scenario.

Big Idea:

Systems have inputs and outputs. We can predict what will happen if input is changed.
(4-5 SYSC)

Later big ideas that build on this big idea include:

Assessing with Learning Progressions in Science
Math Science Partnership
File Name: LP_Systems

Northwest Educational Service District 189
Together We Can

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MODELS & DESIGNS

Big Idea: Systems have inputs and outputs. We can predict what will happen if input is changed. (4-5 SYSC)

Formative Assessment Task Cover Sheet

Learning Target 1	
Assessment Task Details	**Teacher Background**
Brief Description of the Assessment Task: Inv. 1-1 Step 6: Walk around and ask students to identify the fulcrum and show where to put their finger to make the load easier to lift and harder to lift.	**Administration Tips:** You might find it helpful to keep a checklist as you walk around. **Suggestions for Instructional Adjustments:** Discuss any errors in thinking with students as you come across them.
Learning Target: Mechanical systems change forces and motions. Inv. 1, Part 1	
Success Criteria: I can show how forces and motion are changed by a simple machine.	
Student Task Sheet Included: no Student Work Samples Included: no	

Learning Target 2	
Assessment Task Details	**Teacher Background**
Brief Description of the Assessment Task: Inv. 1-1 Step 8: Draw two pictures of lever systems. In the first, show where on your lever you press in order to use the least amount of force. In the second, show where you press in order to use the most amount of force. Label the load and effort in each picture.	**Administration Tips:** Either walk around to check student understanding or collect the drawings and provide feedback. **Suggestions for Instructional Adjustments:** Reinforce the learning target and use of vocabulary at the start of the next lesson.
Learning Target: Mechanical systems like levers use fulcrums to make effort easier where the effort is the input and the load is the output. (4-5 SYSC) Inv. 1, Part 1	
Success Criteria: I can diagram a lever that includes a load, fulcrum and effort and makes effort easier or harder.	
Student Task Sheet Included: no Student Work Samples Included: no	

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MODELS & DESIGNS

Big Idea: Systems have inputs and outputs. We can predict what will happen if input is changed. (4-5 SYSC)

Learning Target 3	
Assessment Task Details	**Teacher Background**
Brief Description of the Assessment Task: Inv. 3-1 Step 9: Student Sheet 18. Students diagram four types of pulley systems and describe how the type of pulley changes the advantage. With 3-1, diagram the single-fixed and single-movable pulleys. Continue during 3-2, step 6 with double pulleys.	**Administration Tips:** Model the diagrams on the board for students. Make sure they add labels and use appropriate symbols for load and effort. **Suggestions for Instructional Adjustments:**
Learning Target: Mechanical systems like pulleys use wheels and ropes to make effort easier where the effort is the input and the load is the output. (4-5 SYSC) Inv. 3, Part 1	
Success Criteria: I can diagram a pulley that includes a load, rope, wheel and effort and makes effort easier.	
Student Task Sheet Included: no Student Work Samples Included: no	

Learning Target 4, Assessment Task Letter A	
Assessment Task Details	**Teacher Background**
Brief Description of the Assessment Task: Inv. 1-2 Response Sheet – Levers (Student Sheet 5). Students decide which lever will provide the greatest advantage and explain why.	**Administration Tips:** Be sure that students read and respond to the full question. **Suggestions for Instructional Adjustments:** Review position of the fulcrum for the greatest advantage.
Learning Target: We can predict how much easier a load will be based on the geometry of the system. Inv. 1, Part 2	
Success Criteria: I can explain how types of mechanical systems will affect the amount of effort required.	
Student Task Sheet Included: no Student Work Samples Included: no	

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MODELS & DESIGNS

Big Idea: Systems have inputs and outputs. We can predict what will happen if input is changed. (4-5 SYSC)

<table>
<tr><th colspan="2">Learning Target 4, Assessment Task Letter B</th></tr>
<tr><th>Assessment Task Details</th><th>Teacher Background</th></tr>
<tr><td>Brief Description of the Assessment Task: Inv. 3-1 Response Sheet – Pulleys (Student Sheet 19). Students describe a pulley system that will reduce the effort required in a given scenario.</td><td rowspan="4">Administration Tips: Giving this assessment before teaching two-pulley systems should alleviate students misreading the question and designing a two-pulley system for the answer. We have found that waiting to give this until after you've taught two-pulley systems confuses the students.

Suggestions for Instructional Adjustments: While students should technically describe a single movable pulley system, an argument could be made that the directional advantage in a single fixed pulley would be a realistic option rather than climbing the tree to tie up a rope. However, students need to describe their reasoning in order to show understanding.</td></tr>
<tr><td>Learning Target: We can predict how much easier a load will be based on the geometry of the system. Inv. 3, Part 1</td></tr>
<tr><td>Success Criteria: I can explain how types of mechanical systems will affect the amount of effort required.</td></tr>
<tr><td>Student Task Sheet Included: no
Student Work Samples Included: yes</td></tr>
</table>

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Program Code: 62
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LEVERS & PULLEYS

Big Idea: Systems have inputs and outputs. We can predict what will happen if input is changed. (4-5 SYSC)

Target 4, Assessment: *b) Response Sheet—Pulleys*

Formative Assessment Student Work Cover Sheet

Student Work Description

Sample 1: This student understood how the mechanical advantage related to the effort required.

Sample 2: While the student indicated the correct type of pulley, there is a misconception between the terms “effort” and “weight.”

Sample 3: This student chose the wrong type of pulley and did not address the need for any kind of advantage, whether directional or mechanical.

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Name _____

Date 1 _____

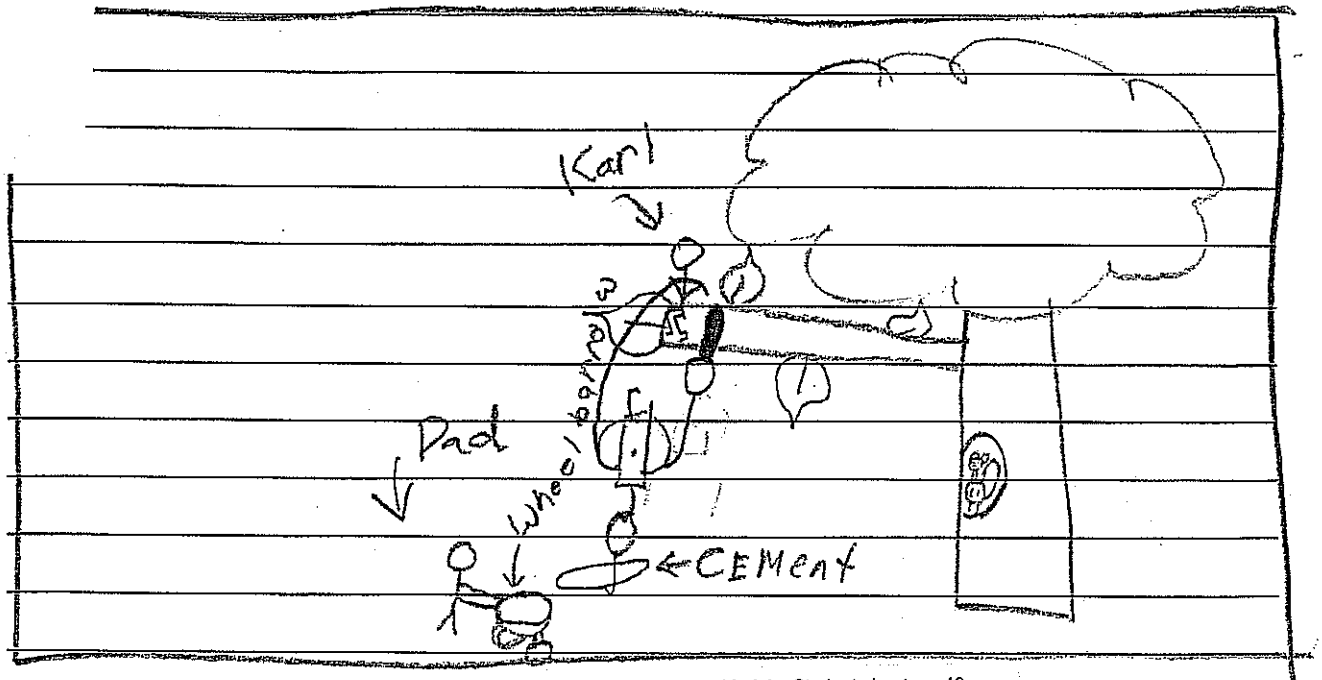
RESPONSE SHEET—PULLEYS

Karl told his brother Charles, "I just couldn't lift that 30-kg bag of cement into Dad's wheelbarrow until I got a pulley and a rope. Then it was easy."

Charles was surprised. "You got the cement into the wheelbarrow!? How did you do it? How much easier was it?"

Explain how you think Karl lifted the cement and how much effort he had to apply.

I believe Carl used a single-moveable. I think he used it, because it would give him a mechanical advantage, cutting the weight in half. It would be twice as easy, because the weight was half as much. Since the cement weighs 30, and by using a moveable it is cutting the weight to 15, it means he would only need half the effort that it would take lifting by hand.



FOSS Landforms Module, Student sheet no. 19, Response Sheet-Pulleys, 2005 of publication from the teacher guide. Developed at the Lawrence Hall of Science and published and distributed by Delta Education. Copyright © The Regents of the University of California. Used with permission.

Name _____

Date _____

RESPONSE SHEET—PULLEYS

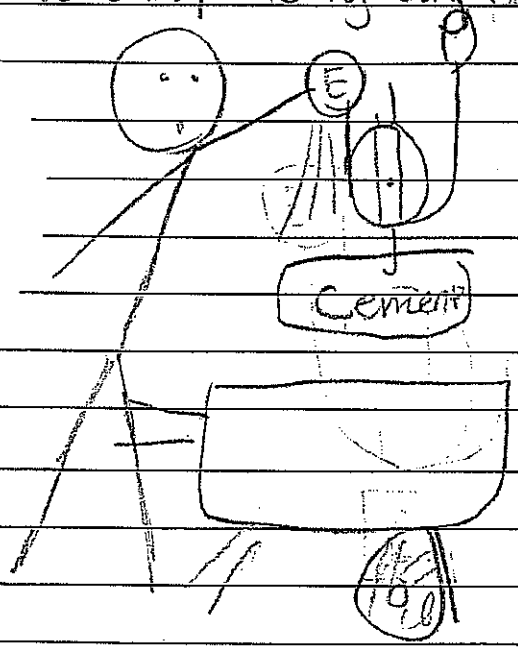
Karl told his brother Charles, "I just couldn't lift that 30-kg bag of cement into Dad's wheelbarrow until I got a pulley and a rope. Then it was easy."

Charles was surprised. "You got the cement into the wheelbarrow!? How did you do it? How much easier was it?"

Explain how you think Karl lifted the cement and how much effort he had to apply.

cement

I think Karl hooked it up to a movable pulley because it makes the cement only weigh half the amount, and because you would not need a directional advantage (because the wheel barrow is only about two feet high) than you would only have to carry 15 kg out of 30kg



KEY
L = load
E = Effort

FOSS Landforms Module, Student sheet no. 19, Response Sheet-Pulleys, 2005 of publication from the teacher guide. Developed at the Lawrence Hall of Science and published and distributed by Delta Education.

Name _____

Date _____

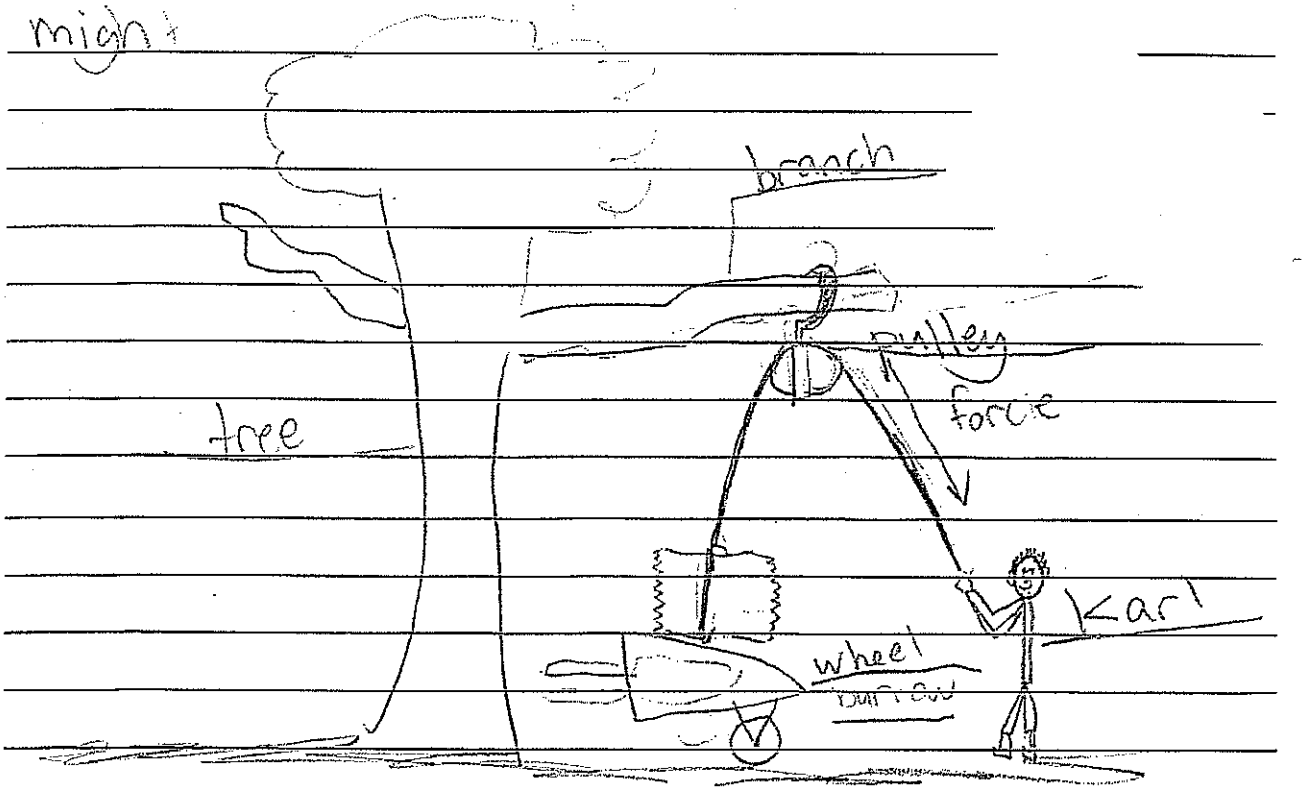
RESPONSE SHEET—PULLEYS

Karl told his brother Charles, "I just couldn't lift that 30-kg bag of cement into Dad's wheelbarrow until I got a pulley and a rope. Then it was easy."

Charles was surprised. "You got the cement into the wheelbarrow!? How did you do it? How much easier was it?"

Explain how you think Karl lifted the cement and how much effort he had to apply.

I think Karl used a V singal fixed pulley. This is how I picture it. I think he tied a rope to the bag of cement then threaded the rope through the pulley then attached the pulley to the tree and pulled down with all his might



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LEVERS & PULLEYS

Additional Information

Included in the documents:

- Glossary of Terms
- 1.1 Investigation Outline
- Spring Scale PowerPoint (Investigation 1.1)
- 1.3 Investigation Outline
- 2.1 Investigation Outline
- 3.1 Investigation Outline
- 3.2 Investigation Outline
- 4.1 Investigation Outline

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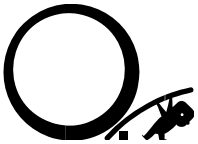

LEVERS & PULLEYS GLOSSARY

1. **Advantage**: a benefit obtained by using a lever (or other simple machine)
2. **Class-1 Levers**: have the fulcrum in the middle and the load and effort at the ends
3. **Class-2 Levers**: have the load in the middle and the fulcrum and effort at the ends
4. **Class-3 Levers**: have the effort in the middle and the fulcrum and load at the ends
5. **Diagram**: a drawing that describes the relationship of all the parts of a system
6. **Directional Advantage**: a change in direction that results from passing a rope through a pulley
7. **Effort**: the force needed to move a load or overcome a resistance
8. **Fixed Pulley**: has a wheel that is attached to something above the load
9. **Fulcrum**: the point where a lever arm pivots
10. **Lever**: a simple machine that people use to gain a mechanical advantage, such as making work easier
11. **Lever Arm**: a stick or beam free to pivot at a point
12. **Load**: the mass lifted or the resistance overcome by a lever
13. **Mechanical Advantage**: reduced the effort (force) needed to lift a load or overcome a resistance; it results from using a simple machine
14. **Movable Pulley**: has a wheel that is attached to the load
15. **Newtons**: effort is measured in newtons
16. **Pulley**: a wheel with a grooved rim in which a rope can run to change the direction of the pull (force) that lifts a load
17. **Simple machine**: any of the six basic devices that provide mechanical advantage, such as pulleys and levers
18. **Two-Coordinate Graphs**: show relationships between two variables

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Levers & Pulleys 1.1: Introduction to Levers

QUESTION: Where should you position the effort in a lever system in order to use the least amount of force?

PREDICTION/HYPOTHESIS:

If _____ then_____

because_____.

MATERIALS: 1 spring scale with rubber band, 1 load with rubber band, 1 modified half-meter stick, 1 binder clip, 1 dowel, 1 pencil-cap eraser, masking tape, heavy textbook

EXPERIMENT

Controlled Variable: _____Manipulated Variable: _____

EXPERIMENT

Procedure:

1. Set up a lever system:
    a. Tape a dowel to the side of a desk so that it sticks out 5 cm
    b. Place a heavy textbook on the end so that it stays in place
    c. Attach a binder clip under the zero position (middle) of the half-meter stick and flip both metal loops up
    d. Slide the metal loops over the open end of the dowel (this is now your lever)
    e. Adjust the location of the binder clip until the half-meter stick is balanced
    f. Slide a pencil-cap eraser onto the open end of the dowel
2. Hang the load at 15 cm
3. Using one finger, press at different points along the opposite side of the half-meter stick
4. Record observations

OBSERVATIONS

Draw two pictures of lever systems in your notebook. In the first, show where on your lever you should press in order to use the least amount of force. In the second, show where you should press in order to use the most amount of force.

PAUSE HERE AND WAIT FOR FURTHER INSTRUCTIONS

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EXPERIMENT

Procedure:

1. Using spring scales:
    a. Always zero the scale before starting
    b. Always use the scale right side up, never upside down
    c. The measurement is read at the top of the indicator
    d. Pull on the hook at the bottom of the scale until the lever arm is level, then read the effort. This works best if one student pulls the scale while the other student reads the effort.
    e. Stop pulling before the scale goes past the 10-N limit
2. Attach the spring scale by placing the rubber band around the end of the half-meter stick that is opposite the load
3. Explore the different readings you get by placing the spring scale at different points along the half-meter stick.
4. Record the spring scale readings for each point along the half-meter stick on a table in your notebook.

ANALYSIS (What does your data tell you?)

Summary: I discovered that

_____

_____

_____

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CONCLUSION (Answer the original question and explain whether or not your hypothesis was correct)

_____

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Mathematics & Science Partnership under Title II, Part B
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Levers & Pulleys 1.3: Lever Experiment B

QUESTION: What would happen to the effort needed to lift the load if the **effort stayed** at one location and the **load moved** farther and farther from the fulcrum?

PREDICTION/HYPOTHESIS:

If

_____then_____

because_____.

MATERIALS: 1 spring scale with rubber band, 1 load with rubber band, 1 modified half-meter stick, 1 binder clip, 1 dowel, 1 pencil-cap eraser, masking tape, heavy textbook

EXPERIMENT

Controlled Variable: _____Manipulated Variable: _____

EXPERIMENT

Procedure:

1. Set up a lever system: (See instructions from 1.1)
2. Hang the **spring scale at 10 cm**
3. Move the **load** from point to point and use the scale to measure the effort required

OBSERVATIONS

Record your data on Student Sheet #6 and graph your results.

ANALYSIS (What does your data tell you?)

Summary: I discovered that_____

_____

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CONCLUSION (Answer the original question and explain whether or not your hypothesis was correct)

_____

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Levers & Pulleys 2.1: Lever Classes

QUESTION: *Is there any advantage to moving the fulcrum to new locations along the lever arm?*

PREDICTION/HYPOTHESIS:

If _____ *then*_____

*because*_____.

MATERIALS: *1 spring scale with rubber band, 1 load with rubber band, 1 modified half-meter stick, 1 binder clip, 1 dowel, 1 pencil-cap eraser, masking tape, heavy textbook*

EXPERIMENT

Controlled Variable**:** _____***Manipulated Variable*****:** _____

EXPERIMENT

Procedure**:**

1. *Set up a lever system (see 1.1 for instructions)*
2. *Attempt different arrangements of the load, effort, and fulcrum to see if any provide an advantage.*

OBSERVATIONS: *Draw diagrams of your new lever systems in your notebook.*

ANALYSIS (What does your data tell you?)

Summary: *I discovered that*_____

_____

_____

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CONCLUSION (Answer the original question and explain whether or not your hypothesis was correct)

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CFDA 84.366B

Levers & Pulleys 3.1: One-Pulley Systems

QUESTION: *Does a pulley provide an advantage when lifting a load?*

PREDICTION/HYPOTHESIS:

If _____ *then*_____

*because*_____.

MATERIALS: *1 half-meter stick, 1 binder clip, 1 spring scale with paper clip, 1 load with rubber band, 1 single pulley, 1 75cm rope, 1 heavy textbook, duct tape*

EXPERIMENT

Controlled Variable: _____***Manipulated Variable***: _____

EXPERIMENT

Procedure:

1. *Set up a pulley system:*
    a. *Clip a binder clip to the end of a half-meter stick*
    b. *Lay the stick on your desk so that only the clip extends over the edge*
    c. *Tape the stick to the desk and place a heavy textbook on the end to hold it in place*
2. *Use the pulley, rope and load to create a pulley system*

OBSERVATIONS: *Draw diagrams of your pulley systems on Student Sheet #18.*

ANALYSIS (What does your data tell you?)

Summary: *I discovered that*_____

_____

_____

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CONCLUSION (Answer the original question and explain whether or not your hypothesis was correct)

_____

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Levers & Pulleys 3.2: Two-Pulley Systems

QUESTION: *What is the advantage (if any) to using two pulleys at the same time?*

PREDICTION/HYPOTHESIS:

If _____*then*_____

*because*_____.

MATERIALS: *1 half-meter stick, 1 binder clip, 1 spring scale with paper clip, 1 load with rubber band, 2 single pulleys, 1 75cm rope, 1 heavy textbook, duct tape*

EXPERIMENT

Controlled Variable*:** _____Manipulated Variable*:** _____

EXPERIMENT

***Procedure*:**

1. *Set up a pulley system (see instructions on 3.1)*
2. *Use the pulleys, rope and load to create a two-pulley system*

OBSERVATIONS: *Draw diagrams of your pulley systems on Student Sheet #18.*

ANALYSIS (What does your data tell you?)

Summary: *I discovered that*_____

_____

_____

_____

_____

CONCLUSION (Answer the original question and explain whether or not your hypothesis was correct)

_____

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Assessing with Learning Progressions in Science
Math Science Partnership
File Name: LP_Inquiry4

Funding information:
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Program Code: 62
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Levers & Pulleys 4.1: Effort in Pulley Systems

QUESTION: Is there a relationship between the number of ropes supporting the load and the effort required to lift the load?

PREDICTION/HYPOTHESIS:

If _____then_____

because_____.

MATERIALS: 1 half-meter stick, 1 binder clip, 1 spring scale with paper clip, 2 loads, 2 single pulleys, 1 75cm rope, 1 heavy textbook, duct tape

EXPERIMENT

Controlled Variable: _____**Manipulated Variable:** _____

EXPERIMENT

Procedure:

1. Set up each pulley system (see instructions on 3.1)
2. Record data on the amount of effort required to lift 2 loads with each system.

OBSERVATIONS: Record your data on Student Sheet #20.

ANALYSIS (What does your data tell you?)

Summary: I discovered that_____

_____

_____

_____

_____

CONCLUSION (Answer the original question and explain whether or not your hypothesis was correct)

_____

_____

_____

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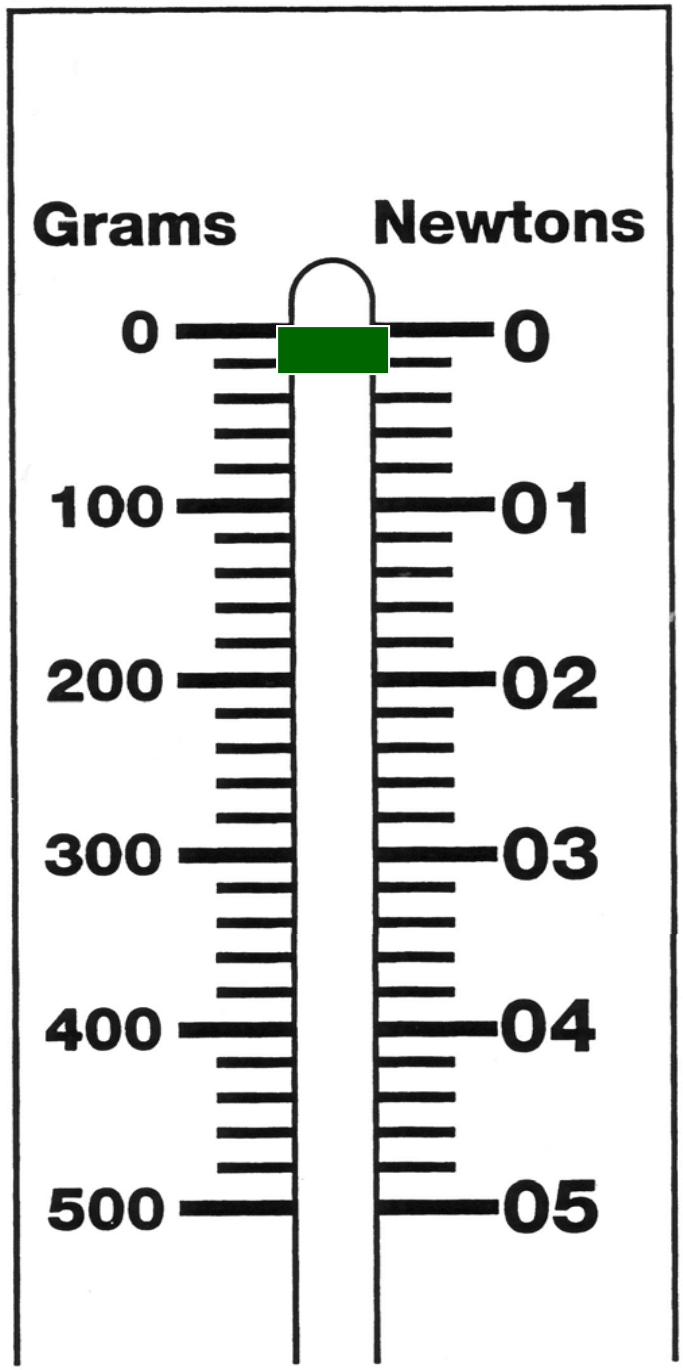
Program Code: 62
CFDA 84.366B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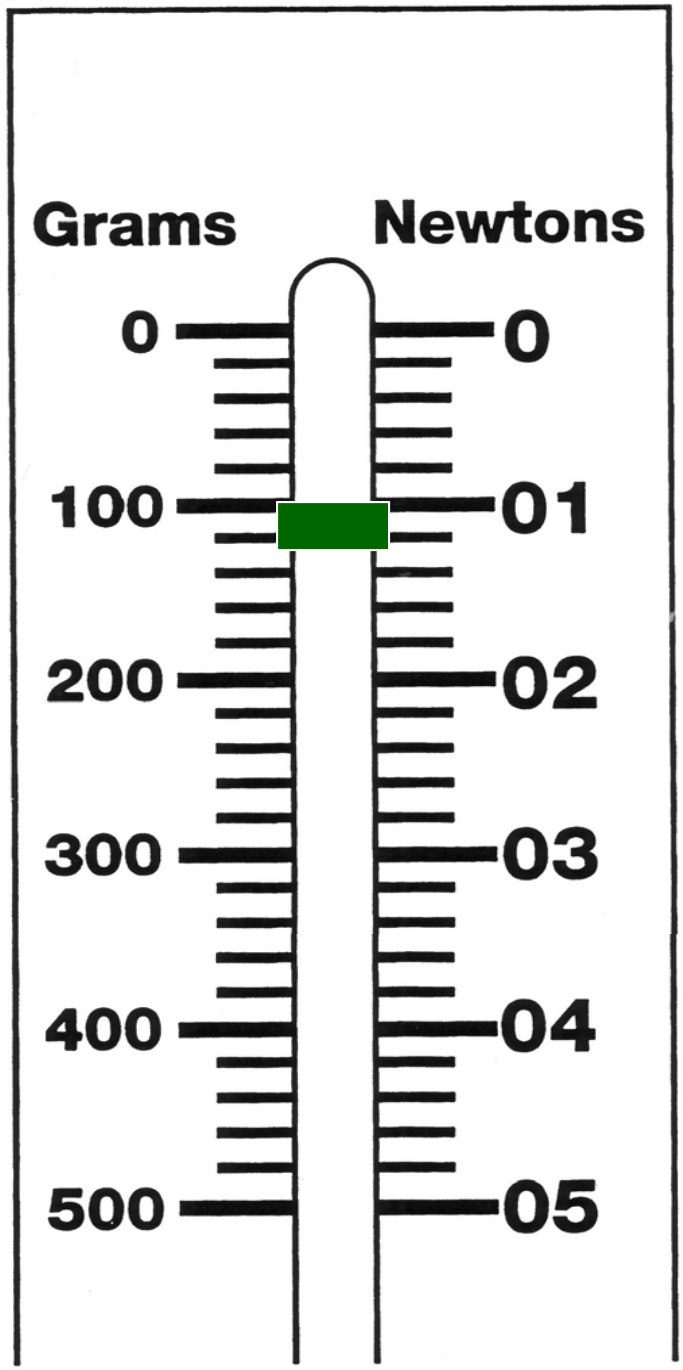
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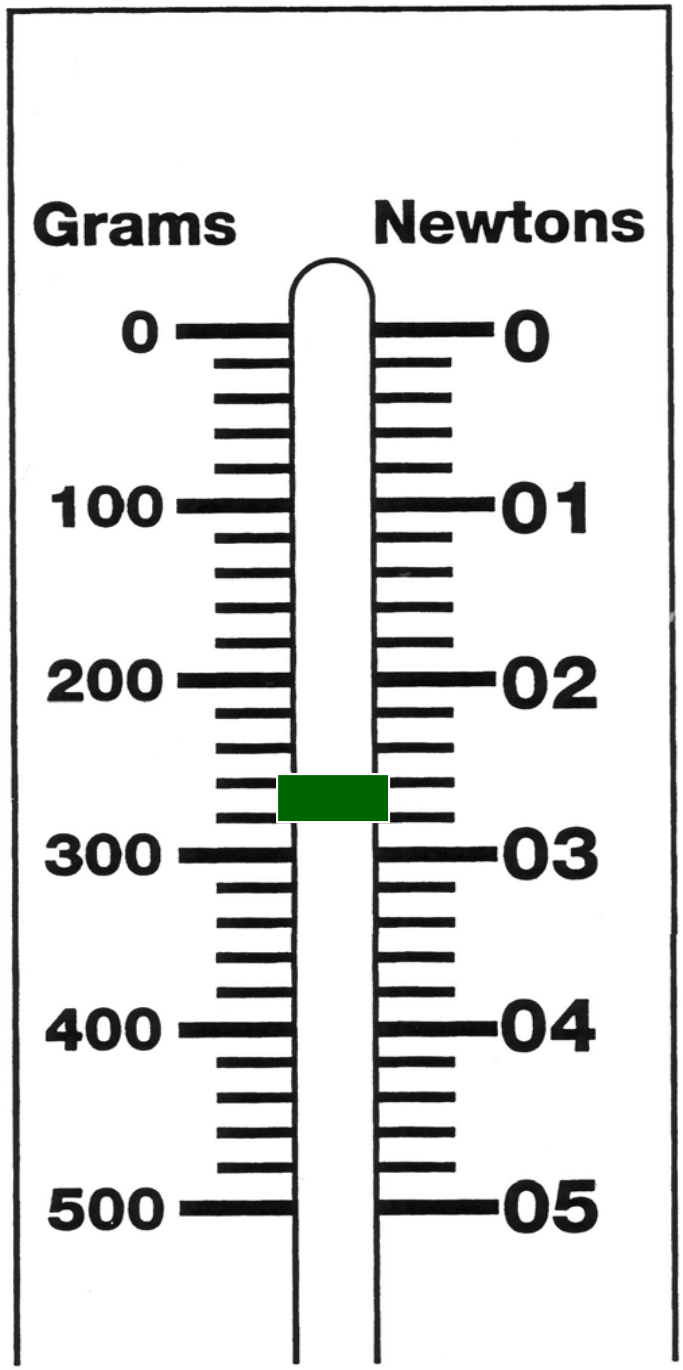
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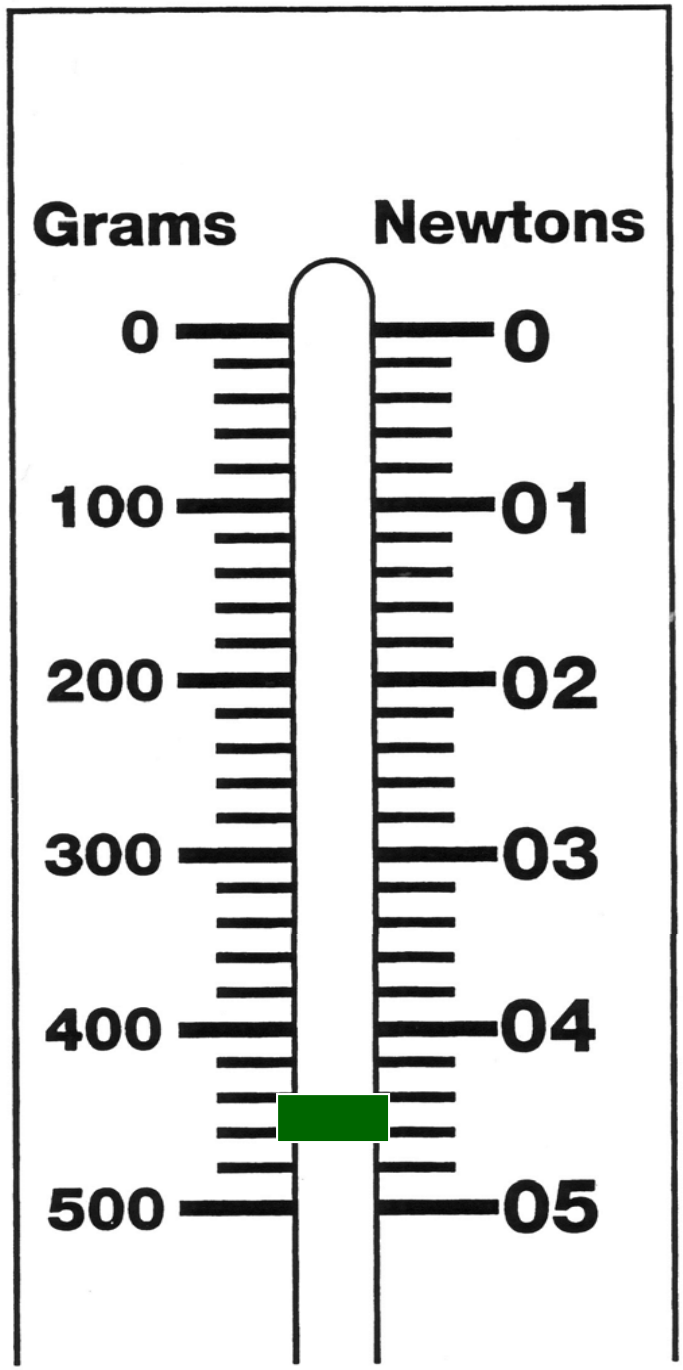
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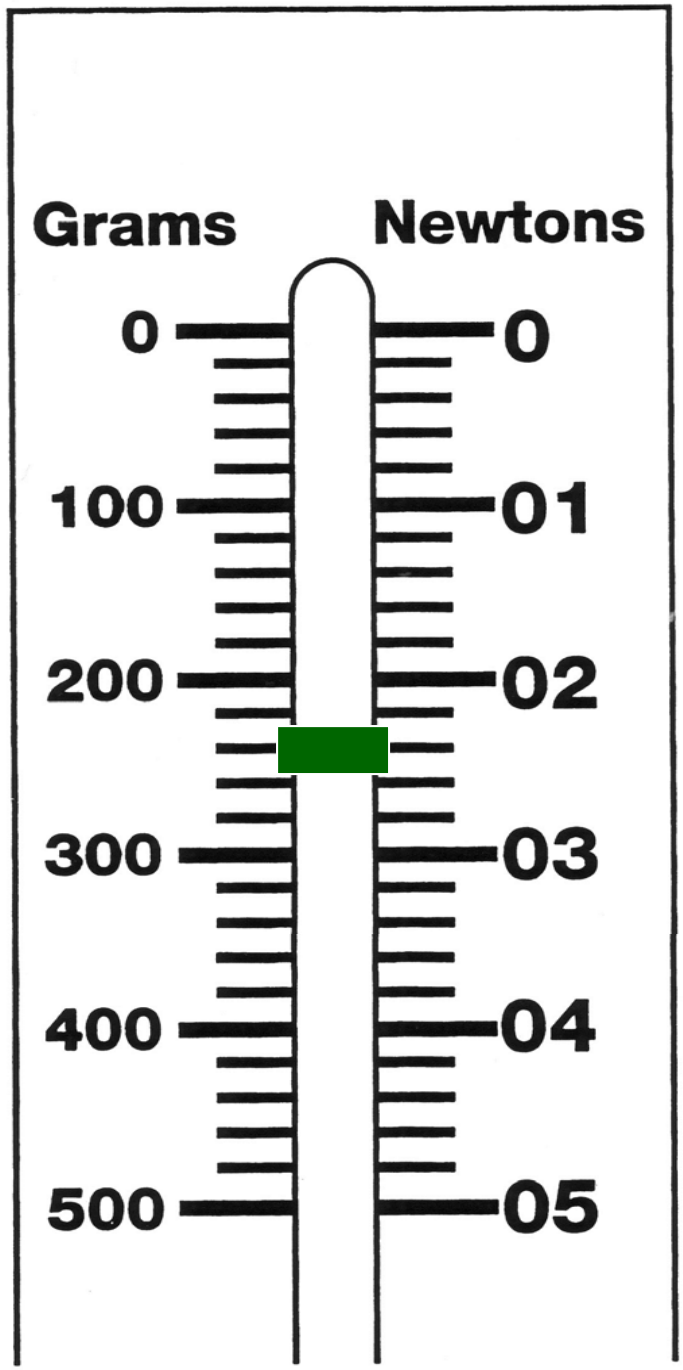
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Levers and Pulleys

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