

Simple Machines: 4.G.2

Inclined Planes and Pulleys

Grade Level	4
Sessions	2 – 50 minutes each
Seasonality	N/A
Instructional Mode(s)	Whole class
Team Size	Whole class
WPS Benchmarks	04.SC.IS.03 04.SC.IS.04 04.SC.IS.05 04.SC.TE.03
MA Frameworks	3-5.IS.03 3-5.IS.04 3-5.IS.05 3-5.TE.1.3
Key Words	Pulley system, Inclined plane, Combined pulley, Fixed pulley, Movable pulley

Summary

The students will learn about the advantages of using inclined planes and pulleys through investigation. They will then apply what they have learned to solve a problem using the engineering design process.

Learning Objectives

2002 Worcester Public Schools (WPS) Benchmarks for Grade 4

04.SC.IS.03 Keep accurate records while conducting simple investigations or experiments.

04.SC.IS.04 Conduct multiple trials to test a prediction. Compare the results of an investigation or experiment with the prediction.

04.SC.IS.05 Recognize simple patterns in data and use data to create a reasonable explanation for the results of an investigation or experiment.

04.SC.TE.03 Identify and explain the difference between simple and complex machines (e.g., hand can opener that includes multiple gears, wheel, wedge gear, lever).

Additional Learning Objectives

1. 04.SC.IS.03 Keep accurate records while conducting simple investigations or experiments.

2. **04.SC.IS.04** Conduct multiple trials to test a prediction. Compare the results of an investigation or experiment with the prediction.
3. **04.SC.IS.05** Recognize simple patterns in data and use data to create a reasonable explanation for the results of an investigation or experiment.
4. **3-5.TE.1.3** Identify and explain the difference between simple and complex machines (e.g., hand can opener that includes multiple gears, wheel, wedge gear, lever).

Required Background Knowledge

1. Basic understanding of simple machines.
2. Basic understanding of the engineering design process.

Essential Questions

1. What are the different types of pulleys?
2. Do using pulleys and inclined planes make doing work easier?

Introduction / Motivation

Ask the students what inclined planes and pulley are and what they are used for? Ask the students for examples of inclined planes and pulleys. (***Inclined Planes / Pulleys***)

Procedure

The instructor will:

1. Divide the class up into groups depending on the number of supplies.
2. Pass out the ***Experiment 1: Inclined Plane*** and ***Data Sheet*** to the groups and the materials needed to do Experiment 1.
3. After all groups have completed the first experiment to pass out ***Experiment 2: Pulleys*** and the materials for the second experiment.
4. When all groups have completed both experiments and answered all questions on the data sheet, the class should discuss their answers.
5. Pass out ***Design Task*** for the students to complete either individually or in their groups.

Materials List

Materials per group	Amount	Location
Books	6-9	Classroom
String	2 pieces (4-5 ft)	Hardware Store
Pulleys	2-3	Hardware Store
Weight	1	Fitness Area of Department Store
Board	1	Hardware Store
Spring Scale	1	Specialty Store
Ruler or Meter Stick	1	Classroom

Materials per student	Amount	Location
Handouts	1	Lesson Plan

Vocabulary with Definitions

1. *Force* - The capacity to do work or cause physical change.
2. *Inclined Plane* – A simple machine with a flat surface that is higher on one end.
3. *Pulley* - This simple machine is made up of a wheel and a rope. The rope fits on the groove of the wheel. One part of the rope is attached to the load. When you pull on one side of the pulley, the wheel turns and the load will move. Pulleys let us move loads up, down, or sideways.
4. *Simple Machine* – Explain that a simple machine is a device that makes work easier.
5. *Work* – Physical or mental effort or activity directed toward the production or accomplishment of something.

Assessment / Evaluation of Students

The instructor may assess the students in any/all of the following manners:

1. Check worksheets

Lesson Extensions

The other lessons in this unit focus on other types of simple machines.

Attachments

1. **Additional Information for Educators**

2. **Experiment 1: Inclined Planes**
3. **Experiment 2: Pulleys** (2 pages)
4. **Data Sheet**
5. **Design Task** (2 pages)
6. **Inclined Planes / Pulleys**

Troubleshooting Tips

None

Safety Issues

None

Additional Resources

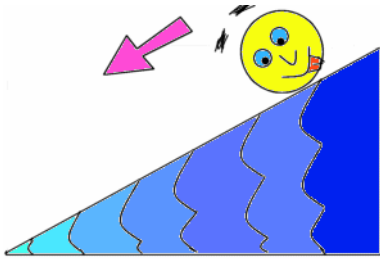
None

Key Words

pulley system, inclined plane, combined pulley, fixed pulley, movable pulley

Additional Information for Educators (from www.smarttown.com)

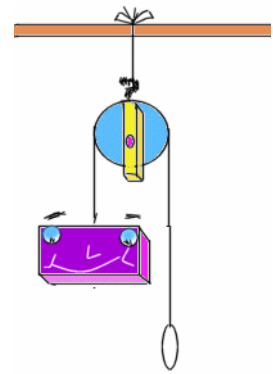
Inclined Plane



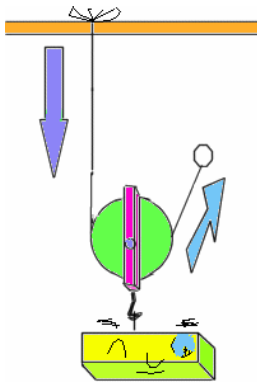
The inclined plane is the simplest machine of all the machines that we have shown you. It is a sloping surface that connects two points together. In common English, we call it a ramp. A screw and a wedge are made up of two inclined planes. The longer the distance of the ramp, the easier it is to do the work, however, it will take a much longer time needed to do the work.

Fixed Pulley

A fixed pulley is the only pulley that when used individually, uses more effort than the load to lift the load from the ground. The fixed pulley when attached to an unmovable object e.g. a ceiling or wall, acts as a first class lever with the fulcrum being located at the axis but with a minor change, the bar becomes a rope.



The advantage of the fixed pulley is that you do not have to pull or push the pulley up and down. The disadvantage is that you have to apply more effort than the load.

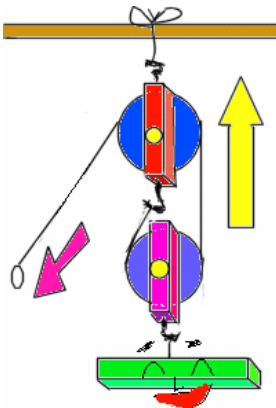


Movable Pulley

A movable pulley is a pulley that moves with the load. The movable pulley allows the effort to be less than the weight of the load. The movable pulley also acts as a second class lever. The load is between the fulcrum and the effort.

The main disadvantage of a movable pulley is that you have to pull or push the pulley up or down. The main advantage of a movable pulley is that you use less effort to pull the load.

Combined Pulley



A combined pulley makes life easier as the effort needed to lift the load is less than half the weight of the load.

The main advantage of this pulley is that the amount of effort is less than half of the load. The main disadvantage is it travels a very long distance.

Name: _____

Date: _____

Experiment 1: Inclined Planes

1. Put a stack of 4-6 books on a desk.
2. Try to rest the board on top of the pile of books creating an inclined plane.



http://www.swe.org/iac/LP/inclined_02.html

3. Tie the weight to a spring scale and lift it vertically till it goes at the same height as the top of the books.

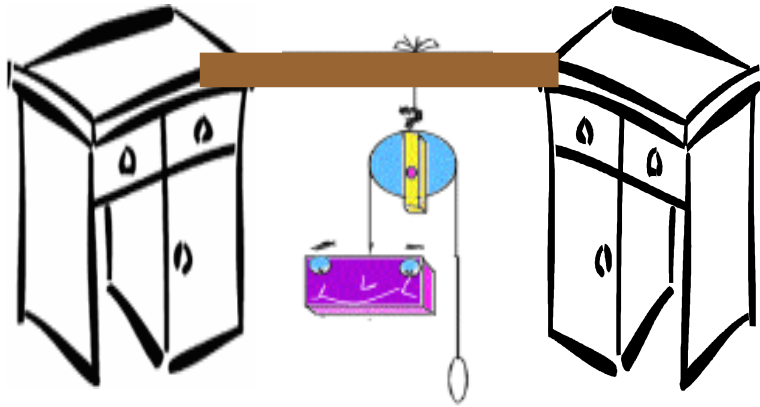
How much force was needed to lift the weight? Record it on your data sheet.
Be sure to measure the length of the inclined plane (the board) and the height of the inclined plane (height of the books) to record on your data sheet.
4. Pull the weight up the incline plane. How much force is needed? Record it on your data sheet.
5. Repeat the experiment using a board of greater length for the inclined plane. How much force is needed? Record it on your data sheet.
6. Add 2 or 3 more books to the pile and repeat the experiment using the first board (the shorter board).
7. Answer the questions on your data sheet about using this type of simple machine.

Name: _____

Date: _____

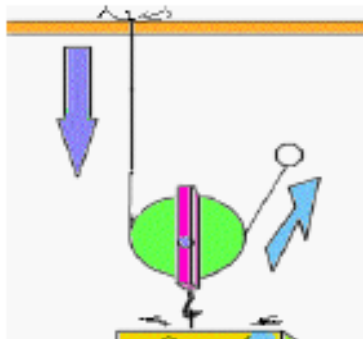
Experiment 2: Pulleys

1. Set-up a fixed pulley like in the picture below. Rest the long board from Experiment 1 between two desks. Tie the fixed pulley to the middle of the board. Attach the weight to one end of the string (the weight is represented by the block). Attach the pull scale to the other end of the string.



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2. Pull down on the pull scale until you lift the weight. Record how much force is needed to lift the weight and measure how high you lift the weight on your data sheet.
3. Set-up a movable pulley for the next test. A movable pulley is shown below.



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Attach one end of the string to the board and the other end of the string to the pull scale.

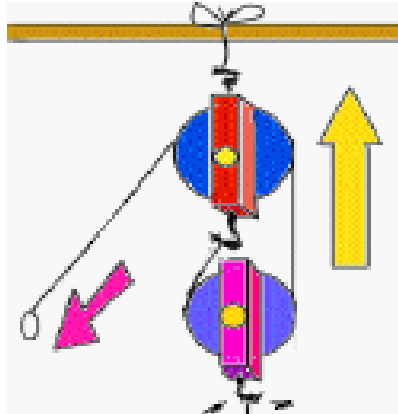
4. Pull up on the pull scale to lift the weight. Lift it the same distance you lifted it using the fixed pulley. Measure the force and record it on your data sheet.
5. Lift the weight again, but this time at a distance twice as long as the first one. Record the force and distance on your data sheet.

Name: _____

Date: _____

Experiment 2: Pulleys

6. Set-up a combined pulley for the next test. A combined pulley is shown below.



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7. Lift the weight with the combined pulley (the weight is represented by the bottom block). Lift the weight the same height it was lifted in the earlier experiments. Record the force and height on your data sheet.
8. Answer the questions on your data sheet.

Name: _____

Date: _____

Data Sheet

Force to lift the weight when no inclined plane was used: _____.

Length of inclined plane	Height of the inclined plane	Force used

What can they say about the relationship of the height and length of the inclined plane and the force used?

Type of pulley	Number of pulleys	Force used

What can you say about the relationship of the type of pulley and force used to lift the weight?

Name: _____

Date: _____

Design Task

Step 1: **Identify the need or problem**

The Worcester Public Library has purchased many new books to be displayed on the second floor. The elevator is broken so it is your job to design a way to get the books to the second floor using pulleys and inclined planes.



<http://www.worcpublib.org/>

Step 2: **Research the need or problem**

The experiments you have done in class with inclined planes and pulleys and thinking about the problem will be your research.

Step 3: **Brainstorm**

Draw three different possible solutions on the back of this paper.

Step 4: **Select the best possible solution**

Circle the solution in Step 3 that you select. Why did you select that solution?

Name: _____

Date: _____

Step 5: **Construct a prototype**

Instead of constructing a prototype, write down the steps you would take in building your prototype. Include the types of materials and tools you would use.

Step 6: **Test and evaluate the solution**

Consider what would happen if your designed prototype were used to lift a tree? How could you improve your design to lift plants outside?

Step 7: **Communicate the solution**

Present your chosen design to the members of your group.

Step 8: **Redesign**

Draw a picture of your new and improved design on the back of this paper. (Use your ideas from Step 6.)

Inclined Planes



www.oxlite.com



www.discountramps.com



Pulleys



<http://www.flag-pole.net>



www.pennplastics.com



<http://www.protowrxs.com>

