Lifting the Load

Summary

Students will compare how much force is needed to lift objects without a pulley, then how much force is needed with a pulley.

Materials

It's "un-Can-ny!"

Can with a plastic lid
1 or more rubber bands, not too strong
2 matchsticks or wooden splints
Weighted mass (e.g., 1/2” galvanized pipe joint or large metal nuts, bolts, washers, etc.)
Poster board cut to the dimensions of the can (sleeve)
Opaque tape (optional)

Lift The Load

For each group:

2-2 1/2 foot lengths of ribbon
Thread spool
2 new pencils
4-8 oz. paper cups
12-4” pieces of string
Tape
6” piece of string
Weights (30 of each): flat or round marbles, pennies, beads, jumbo paperclips, pencil-top erasers, etc.

Additional Resources

Books

- *Simple Machines (Starting with Science Series)*, by Deborah Hodge; ISBN 1550743112
- *How Can I Experiment With…? Force and Motion*, by Cindy Devine; ISBN 1-58952-012-2
- *Science in Seconds for Kids: Over 100 Experiments You Can Do in Ten Minutes or Less*, by Jean Potter; ISBN 0-471-04456-3
- *Science Experiments with Simple Machines (Science Experiments Series)*, by Sally Nankivell-Aston; ISBN 0-531-14579-4

Additional Media

- *Mystery Machines*, by Utah State University Junior Engineering, Logan, Utah (This module available for classroom instruction by contacting Junior Engineering, 435-797-8000; lesson plan available at http://juniorengineering.usu.edu/lessons/machines/machines.php)

Background for Teachers

A simplified definition of work is to make an object move or to change it’s motion. Simple machines are devices that make work easier. All simple machines transfer force. Some change the direction of force, while others change the strength of the force. Still others change both the direction and the strength. Most simple machines make work easier by allowing you to use less force over a greater distance to move an object. Some machines make work easier by allowing you to move things farther and/or faster. In these machines, a larger force is required, but over a shorter distance.

It would be preferable to include more than one pulley system, but due to the nature of the activity, it would involve a considerable amount of time for the students to attempt to build a more complex pulley system. This activity is adequate as a simple comparison between working with and without a pulley.
The invitation to learn is an example of a wheel and axle.

Intended Learning Outcomes

1. Use Science Process and Thinking Skills
2. Manifest Scientific Attitudes and Interests
3. Understand Science Concepts and Principles
4. Communicate Effectively Using Science Language and Reasoning

Instructional Procedures

Invitation to Learn

It's "un-Can-ny!"
Students observe as you place what seems to be an ordinary can on a table. Tell them to watch its movements very carefully. Begin with the can sitting on the table. Focus attention to the fact that it is still and will not move by itself. Next, roll the can gently. It will return to you. Have the students try to figure out why the can returns when it is rolled. You may explain it and show what is happening, or leave it a mystery.
Explanation: The can stores energy in the rubber band because the weight remains in position as the rubber band twists. When the can stops rolling forward, the stored energy in the twisted rubber band propels the can in the opposite direction.
To make a returning can:

- Make two holes in the lid and two in the bottom of the can to attach the rubber bands. Attach the weight to the rubber bands, then run the rubber bands through the holes in the bottom and the lid of the can.
- Secure rubber bands by running a match stick or splint through the loop in the ends. You may want to cover the ends with tape so the rubber bands cannot be seen.
- Practice rolling the can. If you roll it too hard, the rubber bands will allow the weight to spin, and it won't work properly.

Instructional Procedures
Explore how a wheel and axle work to make work easier. Will a wheel and axle make homework easier? Probably not, but it does make some mechanical work easier. Prove this by learning how a wheel and axle work as part of another simple machine called a pulley. Compare how much force is needed to lift objects without a pulley, then how much force is needed with a pulley.
Model for the students and explain how to build the system:

- Assign one student from each group to gather materials.
- Tape the new pencils to a desk or table top with most of the length extending over the side.
- In each cup, tape three 4-inch strings around the outside of the cup, then tape them together at the tips to form a three-armed handle for the cup.
- Take one length of ribbon and attach each end to a cup by running the ribbon through the handle, folding it back to form a small loop, then tape it. Hang this first set of cups over one new pencil.
- Take the piece of string and thread it through the hole in the spool and tie it to make a loop. Put the loop over the second new pencil.
- Attach one end of the remaining ribbon to a cup the same as above. Thread the other end over the spool as it hangs from the pencil, then attach it to the last cup.

- Using the cups without the spool, put items in one cup. Predict how many it will take to lift the cup off the ground and lift the cup to the top. Explain that they will compare this data, using the same items in the cups attached to the pulley.
- Show the students how to complete the *Lift the Load* worksheet. Model how to predict, record the prediction, how to add items, recognize the actual count, and how record it. Model how to work together and take turns.

Assist groups as necessary in constructing pulley systems and beginning the experiments.

Have students compare the force needed to lift their items with and without the pulley system. Log the results on the *Lift the Load* worksheets and draw conclusions about how pulleys make mechanical work easier using the wheel and axle.

Extensions

- Students devise their own pulley system and demonstrate for the class. Even if it fails, they will learn in the process and recognize the scientific process involved in an invention process.
- Integrate the vocabulary of Math Standard V-2a (Probability) when predicting how many items it will take to lift the cup off the ground and lift it all the way to the top. For example, "It is likely that it will take five marbles to lift the cup of five marbles off the ground. It is not likely that only three marbles can lift the cup."
- You may choose to use this lesson as a demonstration only and have students respond verbally or by drawing pictures to record predictions and actual results.

Family Connections

- Students can make and demonstrate their own returning can to family members and teach them how it works. Provide them with a list of necessary materials and assembly instructions.
- Students make their own pulley systems at home and compare the force needed to lift various household items.

Assessment Plan

- Class discussion and responses on the *Lift the Load* worksheet are the primary form of assessment.
- Active participation with the group in building, discussing, and experimenting is another form of assessment.

Bibliography

Research Basis

Joritz-Nakagawa, J. (1992). Spencer Kagan’s Cooperative Learning Structures. *2nd Peace as a Global Language Conference Proceedings & Supplements*, 7-8.

This paper discusses Spencer Kagan’s approach to cooperative learning, which is structured peer interaction and collaboration to achieve a purpose. There are countless structural possibilities that can be used in any learning situation. The article gives examples of some structures. It also mentions structuring activities to involve multiple intelligences to make learning meaningful and accessible to students.

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