**Pulley Lab**

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| Name: Carol Hall | | Date: 7/16/11 |
| Content Area: Physical Science | Grade Level(s): 8th | Topic(s): force, mechanical advantage, simple machines, independent and dependent variables, constants, repeated trials |

**Standards (SOL)**

PS.1 (g) Students will plan and conduct investigations in which independent and dependent variables, constants and repeated trials are identified.

PS.10 (c),(d) Students will investigate and understand scientific principles and technological applications of work, force (measured in Newtons), and mechanical advantage as applied with pulleys.

**Objectives (UKD’s)**

*Students will know that a force is a push or a pull and work is that force over a distance.*

*Students will understand the amount of force needed to lift an object can be reduced using a simple machine.*

*Students will investigate how different pulleys reduce the amount of effort needed to lift objects.*

*Students will explain how the construction of the pulley relates to the mechanical advantage of the machine.*

**Materials & Resources**

Content Teaching Academy References: David Slykhuis, Inquiry in Science Education, 6/27/11, 6:30-8:00 pm

Materials: pulley grooved wheels, string, supports to hang pulleys, 500 grams masses to lift

**Safety Considerations**

*Students will work in small groups with objects that will demonstrate the lab objectives. There are no specific dangers with the objects, but small groups must behave appropriately to allow all members to focus on and understand the lab.*

**Engage – Time Estimate \_\_\_\_\_10 minutes\_\_\_**

*Create interest in pulleys with 2 demonstration pulleys (a fixed and a block and tackle) at the front of the room. Generate curiosity by asking students to lift the object using both pulleys. Raise questions about the force needed to lift the object. Elicit responses to uncover what students know or think about pulleys and simple machines.*

**Explore – Time Estimate \_\_\_\_40 minutes\_\_\_\_**

**Pulley Lab**

*(Students will be grouped in 2 or 3 persons per group. Students will rotate primary construction of pulleys. Students will document data of force needed to lift the 1000 gram mass for each pulley. Pulley diagrams are provided for each pulley and examples are provided in the front of the room for the first two pulleys, only.)*

A *pulley* is a simple machine having a rope that passes over a grooved wheel. A fixed pulley is attached to a solid support and changes the direction of force. The resistance force is the weight of the object being lifted. The input force (your effort) is exerted on the other end of the rope, in opposition to the resistance force.

*Mechanical advantage* is a value that tells the number of times a machine increases the applied force. This tells you how much work the machine is doing for you. In this experiment, you will use a Force Meter to measure the input force (in N) for five different pulley systems and then determine the mechanical advantage of each system.

**OBJECTIVES**

In this experiment, you will

Use a Force Meter to measure force.

Calculate actual mechanical advantage and ideal mechanical advantage.

Determine efficiency.

Make conclusions about pulley systems.

**PROCEDURE**

1. Measure the Resistance Force by attaching the force meter to the weight (load) and lifting it straight up. Write this force number in the data chart below for each of the pulleys.

2. Create each of the pulleys shown on your pulley diagram sheet. The top grooved wheel will attach to a meter stick. The mass (load) will attach to the end of the rope in pulley 1 and then to the hook on the lower grooved wheel for the rest of the pulleys.

When lifting the load, attach the force meter to the free end of the rope and read the force in Newtons it takes to lift the load. This is the input force (your effort). Write this number as you test each pulley.

3. Write the number of ropes that are supporting for each pulley.

4. Show the teacher each of your completed pulleys to have your paper initialed. Your grade will be enhanced as you create each of the pulleys. See the grade column.

**DATA**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Pulley system | Resistance force (N) | Input force (N) | Supporting ropes | Grade | Teacher Initial |
|  | Fr | Fe | IMA |  |  |
| 1 |  |  |  | D |  |
| 2 |  |  |  | D |  |
| 3 |  |  |  | C |  |

a. Identify the Independent Variable:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

b. Identify the Dependent Variables:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

c. Identify the Constants:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

d. Increase the data set of your trials by including the class data for the input force needed to lift the 1000 gram mass for each of their pulleys.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Pulley | Group 1 | Group 2 | Group 3 | Group 4 | Group 5 | Group 6 | Group 7 | Average input force |
| 1 |  |  |  |  |  |  |  |  |
| 2 |  |  |  |  |  |  |  |  |
| 3 |  |  |  |  |  |  |  |  |

**PROCESSING THE DATA**

1. Calculate the actual mechanical advantage for each pulley system using the formula

AMA = **

where AMA = actual mechanical advantage, *Fr* = resistance force, and *Fe* = input force (your effort). Show your work below. Record results in the table that follows Question 3.

2. The ideal mechanical advantage of a pulley is equal to the number of supporting ropes. See the supporting rope numbers in your data table and record the IMA values in the table following Question 3.

3. The efficiency of each pulley system can be calculated using the formula

efficiency = 

Calculate the efficiency of each pulley system. Record the results in the table below.

|  |  |  |  |
| --- | --- | --- | --- |
| Pulley system | AMA | IMA | Efficiency |
| 1 |  |  |  |
| 2 |  |  |  |
| 3 |  |  |  |
| 4 |  |  |  |
| 5 |  |  |  |

4. How did increasing the number of supporting ropes pulleys affect the effort needed to raise the resistance?

5. Discuss two factors that might have caused the efficiency values in this experiment not to be 100 percent.

6. Elaborate on your understanding of pulleys and mechanical advantage by creating two different pulleys with mechanical advantages of 4, 5, 6 or more. Document your data in the table below and include a diagram for each of your pulleys.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Pulley system | Resistance force (N) | Input force (N) | Supporting ropes | Grade | Teacher Initial |
|  | Fr | Fe | IMA |  |  |
| 4 |  |  |  | B |  |
| 5 |  |  |  | A |  |
|  |  |  |  |  |  |

Diagram of pulley system 4:

Diagram of pulley system 5:

**Explain -- Time Estimate \_\_\_\_10 minutes\_\_\_\_**

*Students will share with the class the force needed to lift the 1000 gram mass for each of their first three pulleys. Teacher will facilitate discussions of the increasing mechanical advantage of each pulley. Teach will provide time for the students to develop their explanations of how the pulley construction related to their mechanical advantage.*

**Extend -- Time Estimate \_\_\_30 minutes\_\_\_\_\_**

*Students will construct two more pulleys of their choice that have mechanical advantages greater than the ones they have already constructed.*

**Evaluate -- Time Estimate \_\_\_10 minutes\_\_\_\_\_**

*Teacher will observe the construction of each pulley and initial the final construction of each pulley as complete on the lab worksheets.*

**Plans for Diversity**

*Students of all learning abilities have the opportunity to process and problem solve with this lab. Reading abilities are not essential to excel in this lab. Perseverance is the characteristic most needed for this lab. Many special needs students will do well in the construction of the pulleys. Encourage all students to work hard together to complete each pulley.*

**Connections**

*PS.10 builds upon the concepts of simple machines, force and work. It is intended that students will actively develop scientific investigation, reasoning, and logic skills.*

Students can use their understanding of mechanical advantage of different pulleys to understand and explain the mechanical advantage of other simple machines.