**Introduction** This lab deals with work and simple machines.

**Purpose** To investigate the work done by an inclined plane and pulleys.

**Background**

Work is force times the distance the force is applied on an object. Force and distance are inversely proportional, meaning as one increases, the other decreases. For instance, if the force of doing the work is decreased, the distance must increase *(e.g. wheel chair ramp is much “easier”, but much “farther*”).

There are six types of simple machines used to make work easier: inclined plane, lever, wedge, wheel and axle, screw and pulley. The actual work done (output) does not change.

Inclined planes are a slanted surface which decreases the effort force while increasing the distance applied. Examples include ramps and slanted roofs.

Pulleys include a rope, belt, or chain wrapped around a grooved wheel which can change the direction of a force or the amount of effort force.

Mechanical Advantage is a mathematical advantage assigned to a machine, showing how much easier work can be done by that particular machine versus doing it by hand. It is calculated using force or distance.

**Hypothesis**

If a simple machine is used (inclined plane or pulley), then the work done will not change.

**Materials** wood block 1.2 m and 2.3 m tracks (boards) meter stick

500 g mass 2 single pulleys 500 g spring scale

**Procedures**

1. Do your own version of the lab (*you may use different track length, different objects and masses*) OR use the values provided in the data tables to perform this lab.

2. Part 1: Set up the incline planes as shown in the diagrams. Part 2: Pulleys (*page 3*).

3. Part 1: Pull the wood block up the inclined plane and measure the effort force using a spring scale. Part 2: Lift the 500 g mass using pulley(s).

4. Complete the data tables provided and answers all the questions.

0.8 m

1.2 m track

2.3 m track

Wood block

**Inclined Planes**

Determine the Weight of the Wood Block (resistance force) from the mass.

|  |  |  |  |
| --- | --- | --- | --- |
| **Wood Block** | **320 g** | Divide by 1000 | kg |
| Force of block in Newtons (kg mass x 10) | | | **N** |

ONE METER TRACK – Effort force needed to Pull the Wood Block up the 1 m “ramp”

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Spring Scale Reading Effort Force 260 g** | Divide by 1000 | kg | **Ramp distance** | **Height of ramp** |
| Force of block in Newtons (kg mass x 10) | | **N** | **1.2 m** | **0.8 m** |

**Mechanical Advantage** (1 meter ramp) [MA = length of the ramp / height lifted] SHOW WORK

MA = \_\_\_\_\_\_\_\_\_\_\_\_

**Work Done** (1 meter ramp)[Work = force of block x height lifted]SHOW WORK

Work = \_\_\_\_\_\_\_\_\_ J

TWO METER TRACK – Effort force needed to Pull the Wood Block up the 2 m “ramp”

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Spring Scale Reading Effort Force 180 g** | Divide by 1000 | kg | **Ramp distance** | **Height of ramp** |
| Force of block in Newtons (kg mass x 10) | | **N** | **2.2 m** | **0.8 m** |

**Mechanical Advantage** (2 meter ramp) [MA = length of the ramp / height lifted] SHOW WORK

MA = \_\_\_\_\_\_\_\_\_\_\_\_

**Work Done** (2 meter ramp)[Work = force of block x height lifted]SHOW WORK

Work = \_\_\_\_\_\_\_\_\_ J

30 cm

Spring scale

Pulley with hooks

Pulley with eyes

Spring scale

30 cm

Pulley with hooks

Imagine pulling the 500 g mass UP a distance of 30 cm (0.3 m) using a spring scale (force).

ONE PULLEY SYSTEM – Determine the weight of the 500 g mass.

|  |  |  |  |
| --- | --- | --- | --- |
| **Mass** | **500 g** | Divide by 1000 | kg |
| Force of mass in Newtons (kg mass x 10) | | | **N** |

ONE PULLEY SYSTEM – Effort force needed to lift the 100 g mass 30 cm high (*1 pulley system*)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Spring Scale** | **500 g** | Divide by 1000 | kg | **Spring Scale Distance** |
| Force of mass in Newtons (kg mass x 10) | | | **N** | **0.3 m** |

Height the mass was lifted: \_\_\_\_\_m (nearest tenth)

**Mechanical Advantage** (*1 pulley system*) [MA = distance pulled / height lifted] SHOW WORK

MA = \_\_\_\_\_\_\_\_\_\_\_\_

**Work Done** (*1 pulley system*)[Work = force of weight x Distance lifted]SHOW WORK

Work = \_\_\_\_\_\_\_\_\_ J

TWO PULLEY SYSTEM – Effort force needed to lift the mass 30 cm high (*2 pulley system*)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Spring Scale** | **250 g** | Divide by 1000 | kg | **Spring Scale Distance** |
| Force of mass in Newtons (kg mass x 10) | | | **N** | **0.6 m** |

Height the mass was lifted: \_\_\_\_\_\_\_\_ m (nearest tenth)

**Mechanical Advantage** (2 *pulley system*) [MA = distance pulled / height lifted] SHOW WORK

MA = \_\_\_\_\_\_\_\_\_\_\_\_

**Work Done** (2 *pulley system*)[Work = force of weight x Distance lifted]SHOW WORK

Work = \_\_\_\_\_\_\_\_\_ J

**Conclusions**

Address Hypothesis

Analysis (Optional for this lab)

1. What two measurements are needed to calculate the amount of work done by a simple machine?

2. Compare the amount of work done by each of the two inclined planes that you used in this lab.

3. Which of the two inclined planes had the greatest mechanical advantage?

4. When force is decreased by a simple machine, what is increased?

5. Compare the amount of work done by each of the two pulley systems that you used in this lab.

6. Which of the two pulley systems had the greatest mechanical advantage?

7. What would happen to the mechanical advantage of a third pulley system with three pulleys in this same experiment?

8. What would happen to the amount of work done in question #7?

9. Is the relationship between and force and distance directly *proportional (both increase or both decrease*) or inversely proportional (*one increases, the other decreases and vice versa*)?

Error (Optional for this lab)

**ENRICHMENT (Optional)**

**Calculate the mechanical advantage of the ONE PULLEY SYSTEM**

1. Record the effort force:

2. Record the resistance force:

3. Now divide the resistance force by the effort force:

MA = resistance force (N) =

effort force (N)

**Calculate the mechanical advantage of the TWO PULLEY SYSTEM**

4. Record the effort force:

5. Record the resistance force:

6. Now divide the resistance force by the effort force:

MA = resistance force (N) =

effort force (N)

COMPARISON:

7. Compare the mechanical advantage you calculated for the ONE pulley system using the distance the spring scale was moved [*MA = distance pulled/height lifted*] vs. the resistance/effort force.

8. Compare the mechanical advantage you calculated for the TWO pulley system using the distance the spring scale was moved [*MA = distance pulled/height lifted*] vs. the resistance/effort force.

9. Consider a pulley in which three ropes supports the mass. What would be the mechanical advantage and why?

Inclined Planes

Determine the Weight of the Wood Block

|  |  |  |  |
| --- | --- | --- | --- |
| Wood Block | **320 g** | Divide by 1000 | **0.32 kg** |
| Force of block in Newtons (kg mass x 10) | | | **3.2 N** |

ONE METER TRACK - Effort force needed to Pull the Wood Block up the 1 m “ramp”

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Spring Scale Reading Effort Force **260 g** | Divide by 1000 | **0.26 kg** | Ramp distance | Height of ramp |
| Force of cart in Newtons (kg mass x 10) | | **2.6 N** | **1.2 m** | **0.8 m** |

**Mechanical Advantage** (1 meter ramp) [MA = length of the ramp / height lifted] SHOW WORK

MA = length / height = 1.2 m / 0.8 m

MA = **1.5**

*MA = dE / dR*

**Work Done** (1 meter ramp)[Work = force of block x height lifted]SHOW WORK

Work = **2.6 J**

Work = f d = 3.2 N x 0.8 m

TWO METER TRACK - Effort force needed to Pull the Wood Block up the 2 m “ramp”

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Spring Scale Reading Effort Force **180 g** | Divide by 1000 | **0.18 kg** | Ramp distance | Height of ramp |
| Force of block in Newtons (kg mass x 10) | | **1.8 N** | **2.2 m** | **0.8 m** |

**Mechanical Advantage** (2 meter ramp) [MA = length of the ramp / height lifted] SHOW WORK

MA = **2.9**

MA = length / height = 2.3 m / 0.8 m

*MA = dE / dR*

**Work Done** (2 meter ramp)[Work = force of block x height lifted]SHOW WORK

Work = **2.6 J**

Work = f d = 3.2 N x 0.8 m

PULLEYS

ONE PULLEY SYSTEM - Determine the weight of the 500 g mass.

|  |  |  |  |
| --- | --- | --- | --- |
| Mass | **500 g** | Divide by 1000 | 0.5 kg |
| Force of mass in Newtons (kg mass x 10) | | | **5 N** |

ONE PULLEY SYSTEM - Effort force needed to lift the 100 g mass 30 cm high (*1 pulley system*)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Spring Scale | **500 g** | Divide by 1000 | **0.5 kg** | **Spring Scale Distance** |
| Force of mass in Newtons (kg mass x 10) | | | **5 N** | **0.3 m** |

Height the mass was lifted: 0.3 m (nearest tenth)

**Mechanical Advantage** (*1 pulley system*) [MA = distance pulled / height lifted]

MA = **1**

MA = dE / dR  = 0.3 m / 0.3 m

**Work Done** (*1 pulley system*)[Work = force of weight x Distance lifted]

Work = **1.5 J**

Work = f d = 5 N x 0.3

TWO PULLEY SYSTEM - Effort force needed to lift the mass 30 cm high (*2 pulley system*)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Spring Scale | **250 g** | Divide by 1000 | **0.25 kg** | **Spring Scale Distance** |
| Force of mass in Newtons (kg mass x 10) | | | **2.5 N** | **0.6 m** |

Height the mass was lifted: 0.3 m (nearest tenth)

**Mechanical Advantage** (2 *pulley system*) [MA = distance pulled / height lifted]

MA = **2**

MA = dE / dR  = 0.6 m / 0.3 m

**Work Done** (2 *pulley system*)[Work = force of weight x distance lifted]

Work = **1.5 J**

Work = f d = 5 N x 0.3

**Conclusions**

Address Hypothesis

The hypothesis predicted that if a simple machine is used (inclined plane or pulley), then the work done will not change. This was confirmed in this experiment. The work done by the inclined planes stayed at 2.6 joules and the work done by the pulleys stayed at 1.5 joules.

Analysis

Work is force times the distance the force is applied on an object. Force and distance are inversely proportional, meaning as one increases, the other decreases. For instance, if the force of doing the work is decreased, the distance must increase. This held true for both the inclined planes and the pulleys.

Two of the six types of simple machines were used in this lab and the actual work done (output) did not change.

Inclined planes are a slanted surface which decreases the effort force while increasing the distance applied. Examples include ramps and slanted roofs. The longer inclined plane (more distance: 2.2 m versus 1.2 m) required less effort force (1.8 N versus 2.6 N).

Pulleys include a rope, belt, or chain wrapped around a grooved wheel which can change the direction of a force or the amount of effort force. The two pulley system used needed more distance to pull the mass upward (0.6 m versus 0.3 m), but less effort (2.5 N versus 5 N).

Mechanical Advantage is a mathematical advantage assigned to a machine, showing how much easier work can be done by that particular machine versus doing it by hand. It is calculated using force or distance. For the inclined planes the MA increased for the longer ramp, but work output was the same. For the pulleys, the two pulley system had a greater MA (2 versus 1) than the one pulley system, but the work output was the same.

1. What two measurements are needed to calculate the amount of work done by a simple machine?

*Force & distance are needed to calculate the amount of work done by a simple machine.*

2. Compare the amount of work done by each of the two inclined planes that you used in this lab.

*The work done (work output) does NOT change when using a machine. Machines makes work easier, but do not change the amount of work done.*

3. Which of the two inclined planes had the greatest mechanical advantage?

*The longer the inclined plane, the greater the mechanical advantage.*

4. When force is decreased by a simple machine, what is increased?

*When effort force is decreased, the distance the effort is applied increases.*

5. Compare the amount of work done by each of the two pulley systems that you used in this lab.

*The work does NOT change when using a machine.*

6. Which of the two pulley systems had the greatest mechanical advantage?

*The pulley with two ropes supporting the mass had the greater the mechanical advantage.*

7. What would happen to the mechanical advantage of a third pulley system with three pulleys in this same experiment?

*The MA increases by 1 for each supporting rope. i.e. 3 supporting ropes = MA of 3.*

8. What would happen to the amount of work done in question #7?

*The work does NOT change when using a machine.*

9. Is the relationship between and force and distance directly proportional *(both increase or both decrease*) or inversely proportional (*one increases, the other decreases and vice versa*)?

*W = f x d … force and distance are inversely proportional … as one increases, the other decreases.*

Errors

1) Measuring the spring scale for both aspects of the lab (inclined plane and pulley).

2) Getting confused between work done and mechanical advantage or between the various ways to calculate work and mechanical advantage.

3) Working with the calculations could intimate students to make mistakes.

**ENRICHMENT (Optional)**

**Calculate the mechanical advantage of the ONE PULLEY SYSTEM**

1. Record the effort force: 5 N

(*This is the AVERAGE spring scale measurement when you pulled on the string and lifted the 100 gram mass 30 cm & converted to Newtons in your chart*)

2. Record the resistance force: 5 N

(*This is the spring scale measurement when you lifted the 500 g or 1 kg mass straight up & converted to Newtons in your chart*)

3. Now divide the resistance force by the effort force:

MA = resistance force (N) = 5 N / 5 N = **1**

effort force (N)

**Calculate the mechanical advantage of the TWO PULLEY SYSTEM**

4. Record the effort force: 2.5 N

(*This is the AVERAGE spring scale measurement when you pulled on the string and lifted the mass 30 cm & converted to Newtons in your chart*)

5. Record the resistance force: 5 N

(*This is the spring scale measurement when you lifted the mass straight up & converted to Newtons in your chart*)

6. Now divide the resistance force by the effort force:

MA = resistance force (N) = 5 N / 2.5 N = **2**

effort force (N)

COMPARISON:

7. Compare the mechanical advantage you calculated for the ONE pulley system using the distance the spring scale was moved [*MA = distance pulled/height lifted*] vs. the resistance/effort force.

*Although calculated using different elements, the MA is the same.*

8. Compare the mechanical advantage you calculated for the TWO pulley system using the distance the spring scale was moved [*MA = distance pulled/height lifted*] vs. the resistance/effort force.

*Although calculated using different elements, the MA is the same.*

9. Consider a pulley in which three ropes supports the mass. What would be the mechanical advantage and why?

*The MA increases by 1 for each supporting rope. i.e. 3 supporting ropes = MA of 3.*