Activity 1.1.1 Simple Machine Investigation – VEX

Introduction

In this activity you will explore the function and characteristics of the lever, wheel and axle, and pulley systems. You will see firsthand how simple machines manipulate energy to create a desired output.

Procedure

For this activity your team of four will construct simple machines using VEX components. After you have constructed the simple machines, you will gather data to calculate mechanical advantage. It is important to be as accurate as possible in your measurements and documentation.

Pre-Activity Work

Complete the following in your engineering notebook before you arrive in class to begin the activity.

Define the following terms:

- Effort Force(F_E)**:**
- Resistance Force(F_R)

Watch the Tutorial Video for Vernier Force Probes and LoggerPro and answer the following questions.

1) Watch this video detailing how to conduct a basic friction lab for elementary students to get familiar with the Vernier Force Sensor and Logger Pro software. **http://vnr.st/v69/**
2) Watch the video detailing how to measure the Effort and Resistance forces for an inclined plane to calculate mechanical advantage. **http://vnr.st/v29/**

LoggerPro questions:

A. How do you attach the sensor to the computer?
B. What does it mean to "zero" the Dual Force Sensor and how is it done?
C. Explain how to use the Statistics Tool to obtain the average for a sensor's readings.
D. How to measure the Resistance and Effort force
E. Explain how you hold the dual force sensor to obtain a reliable reading?

First Class Lever 

Setup the VEX lever to function as a 1st Class Lever.

1. Create a scaled annotated drawing of the first class lever you built. Make your drawing detailed enough to show the specific VEX parts involved.

2. Measure and record the d_E, d_R, F_R and F_E.
   - Be sure to measure the resistance force (F_R) with the Vernier sensor in the same orientation as will be used for this simple machine.

d_E	d_R	F_R	F_E

3. Calculate the ideal mechanical advantage of the lever system.

Formula	Substitute / Solve	Final Answer

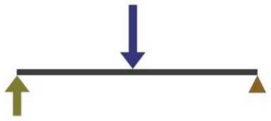
4. Calculate the actual mechanical advantage of the lever system.

Formula	Substitute / Solve	Final Answer

5. Calculate the efficiency of the lever system.

Formula	Substitute / Solve	Final Answer

6. List and describe two examples of a first class lever.

Second / Third Class Lever 

Setup the VEX lever to function as either a 2nd or 3rd Class Lever.

1. Create a scaled annotated drawing of the second or third class lever.

2. Measure and record the d_E, d_R, F_R and F_E.
   - Be sure to measure the resistance force (F_R) with the Vernier sensor in the same orientation as will be used for this simple machine.

d_E	d_R	F_R	F_E

3. Calculate the ideal mechanical advantage of the lever system.

Formula	Substitute / Solve	Final Answer

4. Calculate the ideal effort force that would be needed to overcome the known resistance force if there were not friction or other energy losses.

Formula	Substitute / Solve	Final Answer

5. Calculate the actual mechanical advantage of the lever system.

Formula	Substitute / Solve	Final Answer

6. Calculate the efficiency of the lever system.

Formula	Substitute / Solve	Final Answer

7. List and describe two examples of a second or third class lever.

8. Is it possible for a first or second class lever to have a mechanical advantage less than one, or for a third class lever to have a mechanical advantage greater than one? Justify your answer.

Wheel and Axle 

Setup the VEX Wheel and Axle by adding string to hang the F_R weight and the force sensor.

1. Create a scaled annotated drawing of the wheel and axle system.
2. What is the diameter of the **wheel**?
3. What is the diameter of the **axle**?
4. Wrap the resistance weight around the axle using string. Use the force sensor attached to the string wrapped around the wheel to create equilibrium. Based on where the applied effort and resistance are located, identify the force required to hold the system in equilibrium. Switch and measure in reverse.

Effort force applied to the WHEEL		Effort force applied to the AXLE	
F_E	F_R	F_E	F_R

5. For the same resistance, is the effort force larger when the **effort** is applied to the **wheel** or when it is applied to the **axle**? Explain why.
6. Calculate the ideal mechanical advantage of the wheel and axle system if the **resistance force** is applied to the **wheel**.

Formula	Substitute / Solve	Final Answer

7. Calculate the actual mechanical advantage of your wheel and axle system if the **resistance force** is applied to the **wheel**.

Formula	Substitute / Solve	Final Answer

8. Calculate the efficiency of the wheel and axle system when the **resistance force** is applied to the **wheel**.

Formula	Substitute / Solve	Final Answer

9. List and describe two examples of a wheel and axle.
10. Based on the concepts of mechanical advantage explain why the steering wheel on a school bus so large?

Inclined Plane 

Setup the VEX Inclined Plane using a string attached to the weight and being pulled over the pulley at the top.

1. Create a scaled annotated drawing of the inclined plane system.

2. Calculate the ideal mechanical advantage of the inclined plane system.

Formula	Substitute / Solve	Final Answer

3. Calculate the ideal effort force needed to overcome the known resistance force.

Formula	Substitute / Solve	Final Answer

4. Calculate the actual mechanical advantage of the inclined plane system.

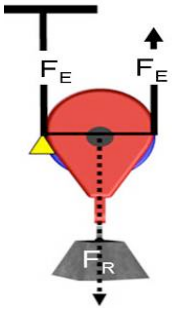
Formula	Substitute / Solve	Final Answer

5. Calculate the efficiency of the inclined plane system.

Formula	Substitute / Solve	Final Answer

6. List and describe two examples of an inclined plane.

Movable Pulley



Design and build movable pulley system in which the pulley <u>moves</u> as the Effort Force is applied to lift the load.

1. Create a scaled annotated drawing of the pulley system.
2. Calculate the actual mechanical advantage of the pulley system.

Formula	Substitute / Solve	Final Answer

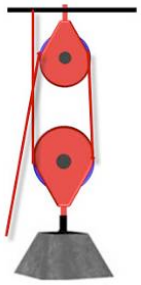
3. Calculate the ideal mechanical advantage of the pulley system.

Formula	Substitute / Solve	Final Answer

4. Calculate the efficiency of the pulley system.

Formula	Substitute / Solve	Final Answer

Block and Tackle



Use string to build a Block and Tackle pulley system with at least two pulleys and three supporting stands on the movable pulley.

1. Create a scaled annotated drawing of the pulley system.
2. Calculate the actual mechanical advantage of the pulley system.

Formula	Substitute / Solve	Final Answer

3. Calculate the ideal mechanical advantage of the pulley system.

Formula	Substitute / Solve	Final Answer

4. Calculate the efficiency of the fixed pulley system.

Formula	Substitute / Solve	Final Answer

5. Describe two examples of a pulley system.
6. In a block and tackle system with a mechanical advantage of 3, the effort is measured at 15 lbf. The resistance, when balanced, is measured at 42 lbf. What factors might account for the loss in energy?

Screw 

Design and build screw using the axle mounted plastic screws in the VEX kit.

1. Create a scaled annotated drawing of the screw system.

2. Calculate the ideal mechanical advantage of the screw.

Formula	Substitute / Solve	Final Answer

3. Calculate the ideal effort force needed to overcome the known resistance force.

Formula	Substitute / Solve	Final Answer

4. Calculate the actual mechanical advantage of the screw.

Formula	Substitute / Solve	Final Answer

5. Calculate the efficiency of the screw.

Formula	Substitute / Solve	Final Answer

6. Describe two examples of a screw.

7. Why do you think overcoming a resistance force using a screw is so easy?

8. The screw is a combination of two simple machines. Identify and defend what two simple machines you believe are combined to create a screw.