Activity 1.2.5

Mechanical System Efficiency – VEX

Distance Learning Support

You must complete this activity in the classroom. Unless your teacher tells you otherwise, skip to **Activity 1.2.5 Mechanical System Efficiency – SIM.**

INTRODUCTION

Energy cannot be created or destroyed, but energy can be converted from one form to another. An engineer creates an **energy conversion** system by design to change an input energy form into a desired output energy form. However, within a conversion system, input energy can be changed into less desirable forms of energy. Less desirable forms of energy conversion can occur due to **resistance** and **friction**, resulting in conversion to **thermal energy**. Engineers strive to decrease undesirable energy conversions within a system, or energy "losses", by planning with system **efficiency** in mind. Efficiency is the ratio of desired output energy compared to input energy.

$$\text{Efficiency}(\%) = \frac{P_{out}}{P_{in}} \cdot 100$$

A common form of energy conversion today occurs through **electromagnetic induction**. Electromagnetic induction transfers mechanical energy into electrical energy. The electrical energy is then transmitted to industries and homes to be used in a variety of ways, many of which include conversion back to mechanical energy.

EQUIPMENT

- Winch system and materials
- Permanent marker
- Multimeter
- Stopwatch or another timing device to measure time to 1-second precision
- Variable power supply with current and voltage display and power supply user manual

RESOURCES

Work, Energy, and Power

Winch Construction Guide Using VEX Robotics Platform

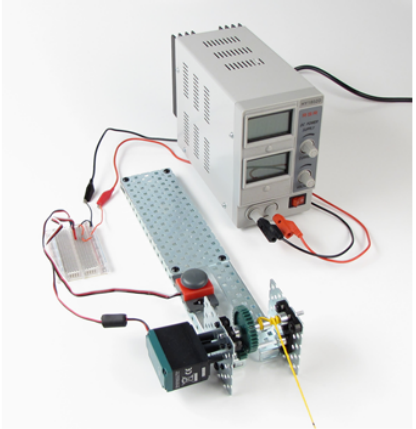
Procedure

In this activity, you investigate an energy conversion system designed to change electrical energy into mechanical energy. You will determine the efficiency of the system by collecting data about power input and output. Remember units and precision when recording data in your PLTW Engineering Notebook.

Presentations: Review **Work, Energy, and Power** and **Winch Construction Guide Using VEX Robotics Platform**.

Caution: Consult the user manual for your specific power supply. This procedure is based on the RSR Variable Power Supply, Model HY1802D. Adapt the procedure to the power supply in your classroom.

1. Confirm all connections and parts are functioning correctly and make necessary corrections.
   a. Confirm that connections are correct according to **Winch Construction Guide Using VEX Robotics Platform**.
   b. Turn on the variable power supply.
   c. Turn the current dial fully clockwise so that the power supply will deliver a constant voltage.
   d. Turn the voltage clockwise until the voltage display is approximately 7.2 V (7–7.5 V is acceptable).
   e. Press the bump switch briefly and confirm that the winch turns.
   f. Remove leads from the front of the variable power supply and plug the leads in with the colors reversed.
   g. Press the bump switch briefly and confirm that the winch turns in the opposite direction.

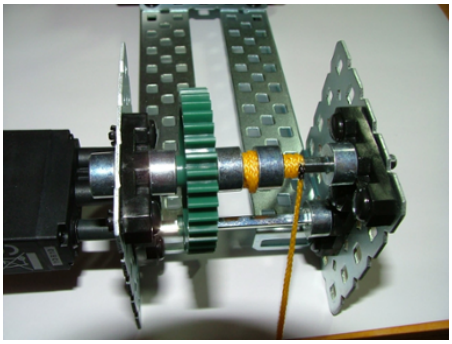


2 Measure and record both weights to attach to the winch.
Mass 1 to be lifted = _____ g (0.0) Convert to _____ Newton (N) (0.000)

Mass 2 to be lifted = _____ g (0.0) Convert to _____ Newton (N) (0.000)

3 Attach the weight. Place the device so that the weight freely hangs from the edge of a table.

4 Using a permanent marker, mark the winch cable a few inches below where the cable wraps around the shaft. Measure 15 cm down and mark a second point using a permanent marker. These are your winch start and stop points.



Length to be lifted (distance between start and stop point) = _____ cm (0.0)

Convert to _____ meters (m) (0.000)

5 Use the bump switch and color coding of the leads in the power supply to operate your winch. Wind the winch cable until the start mark reaches the winch shaft.

a. Start the winch winding upward with the bump switch.
b. Start the stopwatch when the start mark reaches the shaft.
c. Record the voltage and current displayed on the variable power supply.
d. Stop the stopwatch when the stop mark reaches the winch shaft.

Mass to be lifted = _____ g (0.0)

Convert to _____ Newton (N) (0.000)

Voltage = _____ V (0.0)

Current = _____ A (0.0)

Time = _____ s (0.0)

6 Unwind the winch cable so that the start mark on the winch cable is lined up with the winch axle.

7 Add a second weight. Repeat step 5 using two weights.

Mass to be lifted = _____ g (0.0)

Convert to _____ Newton (N) (0.000)

Voltage = _____ V (0.0)

Current = _____ A (0.0)

Time = _____ s (0.0)

Work involves the amount of **force** (**F**) exerted over a specific **distance** (**d**). Work is not related to time. If two winches lift identical weights the same distance, they do the same work, even if one winch takes longer.

Use the following formula to determine how many **joules** (**J**) of work it took to lift the weight in the system. As you carry your units through to the solution, change the final answer from N·m to the equivalent J.

8 Determine the work done by the winch system.

Formula	Substitute / Solve	Final Answer (0.000)
Work = d · F (use units m · N)		

Power involves time, force, and distance. Two winches, one slow and one fast, do the same amount of work to lift a given weight through a given because they use the same force and cover the same distance. Time is not a factor. But to cover the distance faster, the faster winch uses more power.

9 Use the following formula to calculate the output power of the system in **watts** (**W**). As you carry your units through to the solution, change the final answer from J/s to the equivalent W. Determine the output power

of the system.

Formula	Substitute / Solve	Final Answer (0.000)
$P_{out} = \frac{W_{out}}{t}$		

10 To calculate the power of an electrical system in watts, multiply current and voltage. Substitute and solve to discover how many watts were put into your system. As you carry your units through to the solution, change the final answer from A·V to the equivalent W.

Formula	Substitute / Solve	Final Answer(0.000)
$P_{in} = IV$		

11 To compare the energy input versus the output, you must determine the efficiency of the system. Use the following formula to calculate efficiency.

Formula	Substitute / Solve	Final Answer (0.0)
$\text{Efficiency}(\%) = \frac{P_{out}}{P_{in}} \cdot 100$		

CONCLUSION

1. List and describe three factors that reduced efficiency in the winch system.
2. Describe one strategy for making the system even more efficient.
3. Explain two or more reasons automotive engineers are concerned with eliminating inefficiency from vehicles.

Proceed to next activity