# Assignment Information

**Purpose** To use a computer simulation to help choose the best solution to a complex real-world problem

**Time** Approximately 60 minutes

**Question** Which solution should be used to remove the boulder from the land?

**Summary** In this simulation, you are tasked to remove a boulder from a piece of land. You will analyze three solutions based on the machines used, impact on the land, the amount of time used to accomplish the task, and cost. You will choose the best solution and justify your choice using your observations, data, and mathematical processes.

# Background Information

Simple machines are tools that can be used to make tasks and jobs easier. The six simple machines are the inclined plane, wedge, screw, lever, wheel and axle, and pulley.

The inclined plane is a sloping surface, such as a ramp, that is used to lift objects. A wedge looks like two inclined planes placed back to back. It is used to split things apart. A screw can hold things together. A lever is a strong bar that turns about a fulcrum, or fixed point. It can be used to lift heavy objects. A force applied at one end of a lever is transmitted to the other end of the lever. A seesaw is an example of a lever. A wheel and axle consists of two circular objects of different sizes that are connected. This simple machine moves objects across a surface. Roller skates have wheels and axles that can move you from one place to another! A pulley consists of a grooved wheel and a rope. Pulling the rope lifts objects. Flagpoles and cranes have pulleys.

Simple machines have a property called mechanical advantage, which is a measure of how easily a machine can perform a task. A mechanical advantage of 4 means that in the absence of friction, the machine ideally multiplies the applied force by a factor of 4.

# Assignment Instructions

1. **Prepare for the project.** 
   1. Read through this guide before you begin, so you know the expectations for this project.
   2. If anything is unclear, be sure to ask your teacher.
2. **Consider the characteristics of the best solution.** 
   1. Gain access to the simulation.
   2. Read the introduction and then select “Next.”
   3. Understand the requirement and constraints of the best solution. A requirement is what the best solution is supposed to accomplish and the constraints are the limitations of the best solution. This information will guide you in making the best choice.

The requirement of the best solution is the following.

* The solution should use simple machines that can do the task the easiest.

The constraints of the solution include the following.

* The solution should limit the work hours used to a minimum of 4.
* The solution should use less money for the use of trucks/tractors.

1. **Analyze each solution to identify the best one.**
   1. Read the instructions on the screen.

You must choose the solution that will be the most cost-efficient and minimize the impact on the land. Explore each solution.

* 1. Select one of the solutions.
  2. Observe the images that show the plot of land before and after the machines were used. Observe the before image. Then, use the right arrow to view the after image. Be sure to read the descriptive text so you know what is happening in the images.
  3. Select the marker on the land to observe the impact of this solution on the plot of land. Record your observations in Table A in the Data and Analysis section of this document. Select X at the top right of the screen to continue.
  4. Select the marker on the truck to determine the number of work hours it took for the task to be accomplished. Record the Start time in Table A. Select the right arrow. Record the End time in Table A. Determine the number of work hours spent by subtracting the End time from the Start time. Work hours refer to the number of hours it took one person to accomplish the task. Record the number of work hours spent in Table A. Select X at the top right of the screen to continue.
  5. Select the second marker on the truck to determine the qualitative cost of the solution. Record the Starting fuel level in Table A. Select the right arrow. Record the Final fuel level in Table A. Determine the qualitative fuel cost by using the table below. Record the qualitative cost in Table A. Select “Next” to continue.

|  |  |
| --- | --- |
| **Fuel Level Change** | **Qualitative Cost** |
| Between full to empty | $$$ |
| Between full to half empty | $$ |
| Between full to and three fourths full | $ |

* 1. Repeat Steps 3b–3f for the other two solutions.

1. **Identify the combination of simple machines that would remove the boulder in the most efficient manner.**
   1. Read the instruction on the screen. Before you choose the best option, complete step 4b. The information in this step will help you determine the best option.
   2. Read the passage about mechanical advantage and fractions.

Recall that mechanical advantage is a measure of how easily a machine can perform a task. The higher the value of the mechanical advantage, the easier it is for the simple machine to accomplish a task.

Recall also that the mechanical advantage of a lever is calculated by dividing *a* by *b* or, where *a* is the length of the lever on the side where the force is applied and *b* is the length of the lever where the force is being transferred. The mechanical advantage of a ramp is calculated by dividing the length of the ramp (*L*) by its height (*H*) or .

Consider these sets of fractions and their quotients.

Set A:

= 0.5 and = 5

Set B:

= 4 and = 5

What observations can you make here? For Set A, if a fraction has a numerator (the number on top) that is lesser than its denominator (the number on the bottom), its quotient (the answer to a division problem) will be lesser than a fraction whose numerator is greater than its denominator. For Set B, if two fractions have different values for the numerator but the same values for the denominator, the fraction whose numerator is greater will result in a greater quotient.

* 1. Use what you know about the mechanical advantage of levers and ramps and what you learned about fractions to complete this step.

1. For the lever, compare the lengths of *a* and *b* in all four options and predict which lever has the highest mechanical advantage.
2. For the ramp, compare the lengths of *L* and *H* in all four options and predict which ramp has the highest mechanical advantage (hint: the height of all the ramps are the same).
3. From your analysis, predict which combination will be the most efficient. The combination that has the highest mechanical advantage for the lever and ramp will be the most efficient.
   1. Based on your comparisons, choose and select the best option. Click through the scenes of your predicted best option using the right arrows to observe what happens when the lever and ramp is used. Note that the same amount of force is used in pushing the boulder up the ramp in all the four scenarios. Record your observations in Table B. Use this as your guide. Select X to choose another option.

|  |  |
| --- | --- |
| Option 1 | Option 2 |
| Option 3 | Option 4 |

* 1. Select the other 3 options to observe what happens to the boulder when the levers and ramps are used. Record your observations in Table B.
  2. After you have recorded your observations in Table B, select “Next.”

1. Calculate the mechanical advantage of the simple machines.
   1. Write the formula used to determine the mechanical advantage of a lever in Table C and the formula used to determine the mechanical advantage of a ramp in Table D.
   2. Look at the values of *a*, *b*, *L*, and *H* of the best option. Use the formulas you wrote in Tables C and D to determine the mechanical advantage of the lever and the ramp in the best option. Drag the correct values for the mechanical advantage of both the lever and the ramp to the appropriate location. Record the correct values in Table C for the lever and Table D for the ramp.
   3. Use the *a* and *b* values in Table C to determine the mechanical advantage of the levers in the other three options. Record the mechanical advantage values in the last column of Table C.
   4. Use the *L* and *H* values in Table D to determine the mechanical advantage of the ramps in the other three options. Record the mechanical advantage values in the last column of Table D.
2. **Answer the Follow-Up Questions.**
3. **Submit your Student Guide in the Virtual Classroom or to your teacher.**

**Data and Analysis**

Record your data/observations and take note of your analysis in the tables below.

**Table A. Comparison of Solutions**

|  |  |  |  |
| --- | --- | --- | --- |
| **Solution** | **Observations/Data** | | |
| **Impact on land** | **Number of work hours** | **Qualitative cost** |
| **Pulley and truck** |  | Start time: | Starting fuel level: |
| End time: | Final fuel level: |
| Number of work hours: | Qualitative cost: |
| **Wedge, hammer, and tractor** |  | Start time: | Starting fuel level: |
| End time: | Final fuel level: |
| Number of man-hours: | Qualitative cost: |
| **Lever, ramp, and truck** |  | Start time: | Starting fuel level: |
| End time: | Final fuel level: |
| Number of work hours: | Qualitative cost: |

**Table B. Observations on Four Options**

|  |  |
| --- | --- |
| **Option** | **Observations** |
| 1 |  |
| 2 |  |
| 3 |  |
| 4 |  |

**Table C.** **Properties and Mechanical Advantage of the Levers in the Four Options**

|  |  |  |  |
| --- | --- | --- | --- |
| **Formula used to determine mechanical advantage:** | | | |
| **Option** | **Properties of Simple Machine** | | |
| ***a* (m)** | ***b* (m)** | **Mechanical Advantage** |
| 1 | 0.6 | 1.2 |  |
| 2 | 1.5 | 0.3 |  |
| 3 | 0.2 | 1.6 |  |
| 4 | 1.5 | 0.3 |  |

**Table D. Properties and Mechanical Advantage of the Ramps in the Four Options**

|  |  |  |  |
| --- | --- | --- | --- |
| **Formula used to determine mechanical advantage:** | | | |
| **Option** | **Properties of Simple Machine** | | |
| ***L* (m)** | ***H* (m)** | **Mechanical Advantage** |
| 1 | 1.0 | 0.5 |  |
| 2 | 2.0 | 0.5 |  |
| 3 | 3.0 | 0.5 |  |
| 4 | 3.0 | 0.5 |  |

# Follow-Up Questions

Answer the following questions.

* 1. Based on Table A, which is the best option? Explain why you think it is the best option. Use your knowledge of simple machines and your observations to support your answer.
  2. Was your prediction of the best combination of machines correct? What would you have done differently to make an accurate prediction?
  3. Which machine combination is the most effective in moving the boulder from the ground to the truck? Use Tables C and D to answer your question and in your explanation.