1103 Per 10 Solutions: Simple Machines - Pulleys

10.1 What is the Mechanical Advantage of a Pulley System?

1) **Mechanical advantages of pulley systems:**

Machines can reduce the amount of force needed to raise a load. This property is called the mechanical advantage of the machine. The mechanical advantage tells how many times the machine multiplies the input force to raise a load (the output force).

a) Examine the pulley system on your table. Hang a weight from the bottom of the moveable pulley. Pull the string a distance of 20 cm to raise the weight. Then measure the distance that the weight was raised. ____________

b) Calculate the ideal mechanical advantage of this pulley system.

c) Explain how you could have determined the ideal mechanical advantage of this system without making any measurements of the distances involved.

2) **Mechanical advantages of a block and tackle:** Your instructor will demonstrate lifting cement blocks with a block and tackle.

a) Calculate the actual mechanical advantage of the block and tackle.

1) How much weight did the block and tackle lift? ______________

2) How much force was needed to lift it? ______________

3) Using these data, calculate the actual mechanical advantage of the block and tackle.
b) Find the ideal mechanical advantage of the block and tackle.
   1) How high off the floor were the cement blocks lifted?  ________________

   2) Through what distance was the rope pulled to lift them?  ______________

   3) Using these data, calculate the ideal mechanical advantage.

   4) How well does your calculation agree with the ideal mechanical advantage found
      from counting supporting rope segments?  _________________________________

c) Compare your calculations of the actual mechanical advantage and the ideal
mechanical advantage. Why would one value be larger than the other?

10.2 How Much Work is Done by Machines? How Efficient Are They?

3) Efficiency of the block and tackle:
   a) How much weight did the block and tackle lift?  ________________
   b) How high off the floor were the cement blocks raised?  ______________
   c) Find the work done on the blocks to raise them. This is the work out.
      ________________
   d) How much force was needed to raise the blocks?  ________________
   e) Through what distance was the rope pulled to lift them?  ______________
   f) Find the work done when you pull the block and tackle rope. This is the work in.
      ________________
   g) Calculate the efficiency of the block and tackle.
10.3 What is the Efficiency of Different Pulley Systems?

Use a newton scale and a meter stick to collect data for each of the three pulley systems in the classroom. The pulleys are attached to 2 kg masses, or a weight of about 20 newtons (2 kg x 9.8 m/s² = 19.6 N). Measure the force each pulley system needs to hold this weight motionless above the floor.

Record your data in the table below. Then calculate the mechanical advantages and the efficiency of each system in the space below the table.

<table>
<thead>
<tr>
<th>Pulley</th>
<th>F_out</th>
<th>F_in</th>
<th>MA_actual</th>
<th>D_in</th>
<th>D_out</th>
<th>MA_ideal</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>20 N</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#2</td>
<td>20 N</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#3</td>
<td>20 N</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a) In the space below, show your calculations for each of the three pulley systems.

**Pulley #1**

1) \( MA_{actual} = \frac{F_{out}}{F_{in}} \)

2) \( MA_{ideal} = \frac{D_{in}}{D_{out}} \)

3) \( Efficiency = \frac{MA_{actual}}{MA_{ideal}} \)
Pulley #2
1) $MA_{\text{actual}}$

2) $MA_{\text{ideal}}$

3) Efficiency

Pulley #3
1) $MA_{\text{actual}}$

2) $MA_{\text{ideal}}$

3) Efficiency

b) Group Discussion Question: You use a pulley to raise a 600 lb piano. You can apply a maximum of 100 lbs of force on the pulley rope. What is the minimum actual mechanical advantage you will need? Approximately what ideal mechanical advantage would you need?
Period 10 Exercises: Simple Machines – Pulley Systems

Write answers to the questions below. Show your mathematical steps and the units of the quantities. This sheet with your answers should be turned in at the beginning of Period 11.

1. Finding mechanical advantage and efficiency:
   The pulley system shown requires 30 pounds of force to lift a 50 pound load.
   a) What is the actual mechanical advantage of this pulley system?
   b) What is its ideal mechanical advantage? ________
   c) What is the efficiency of this system?

2. Using reasoning to solve problems:
   You want to lift a 300-lb car engine using an 8-foot long lever. The maximum force in you can apply is 100 lbs. How long should the lever arm and load arm be so that you can just lift the engine with this lever? (The total length of the load arm plus the lever arm is 8 feet. Assume that the lever is frictionless.)