CHAPTER 3

Teaching Suggestions

Science and Mathematics Lab

(Course 1, Lesson 4-4)

Pulleys

OVERVIEW

This activity provides students with the opportunity to explore the work efficiency of simple machines. Students will be required to measure force and distance to calculate the work required to lift a mass. Students will calculate the efficiency of both a single pulley and a block and tackle.

RECOMMENDED TIME

1 class period

MATERIALS

- 1-m length of cotton string
- 0.5-kg standard mass
- 2 plastic-coated wire ties, 10 cm and 30 cm long
- metric spring scale (calibrated in newtons)
- meterstick
- utility clamp
- masking tape
- 2 pulleys
- ring stand

PREPARATION

No special preparation is needed.

TEACHING THE LAB

Have students work in pairs or small groups.

Answers and Conclusions

1. Sample answer:
Work input for the single pulley is 0.78 J. Work input for the block and tackle is 0.90 J.
Work output for the single pulley is 0.75 J. Work output for the block and tackle is 0.75 J.

2. Sample answer:
Efficiency of the single pulley is 0.96. Efficiency of the block and tackle is 0.83.

3. Sample answer: The work input for the single pulley is less than that for the block and tackle.

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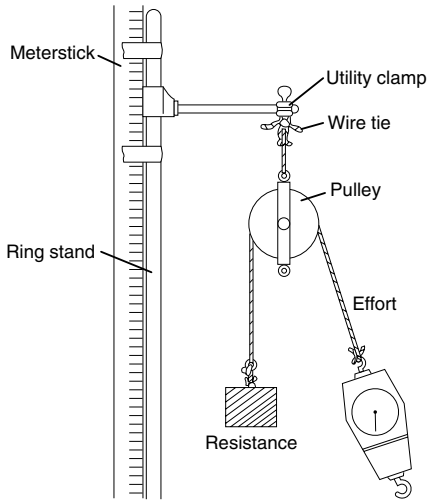
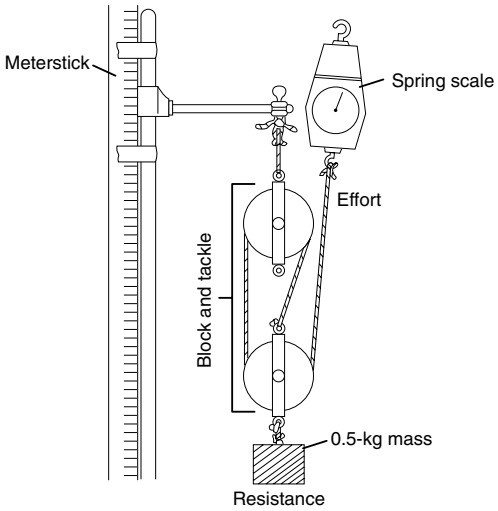
INTRODUCTION

A simple machine, such as a *pulley,* changes the direction of a force and increases either the size of the effort force or the distance the resistance moves. If you have ever raised or lowered a flag or a slatted window blind, you have used a pulley. A single fixed pulley is one that cannot move up or down. A series of pulleys is called a *block and tackle.* You may have seen a block and tackle in an auto repair shop, where it is used to lift car engines.



Single Fixed Pulley



Block and Tackle

OBJECTIVES

In this lab, you will:

- perform work using a single fixed pulley.
- construct a block and tackle and use it to perform work.
- compare the properties of a single fixed pulley and a block and tackle.

MATERIALS

- 1-m length of cotton string
- 0.5-kg standard mass
- 2 plastic-coated wire ties, 10 cm and 30 cm long
- metric spring scale (calibrated in newtons)
- meterstick
- utility clamp
- masking tape
- 2 pulleys
- ring stand

Name _____ Date _____

Science and Mathematics Lab

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Pulleys (continued)

PROCEDURE

Part 1 Single Fixed Pulley

1. Attach the utility clamp to the top of the ring stand. Attach one of the pulleys to the utility clamp with the 10-cm long wire tie.
2. Tie a small loop at each end of the 1-m length of string. Then thread the string through the pulley.
3. Tightly wind the 30-cm wire tie to the 0.5-kg mass. Use the tie to attach the 0.5-kg mass to the spring scale. Record its weight in newtons (N) under Resistance Force in the Data Table.
4. Remove the mass from the spring scale and attach it to one loop of the pulley string. Attach the other loop of the string to the spring scale.
5. Pull the spring scale straight down and measure the force needed to lift the mass 15 cm. Record this value as Effort Force in the Data Table.
6. Measure the length of string required to lift the mass 15 cm. Record this value as Effort Distance in the Data Table.

Part 2 Block and Tackle

1. Remove the 0.5-kg mass and spring scale from the string.
2. Attach the string to the second pulley and thread the string through the pulleys as shown in the figure on page 90.
3. Measure the weight of the 0.5-kg mass by attaching the mass to the spring scale. Record this value in the Data Table under Resistance Force.
4. Attach the mass to the second pulley and then attach the spring scale to the loop on the free end of the string. Pull the scale straight up.
5. Measure the force needed to lift the mass 15 cm and record it in the Data Table.
6. Measure the distance the scale moved to lift the mass 15 cm and record it in the Data Table as Effort Distance.

Name _____ Date _____

Science and Mathematics Lab

(Course 1, Lesson 4-4)

Pulleys (continued)

DATA AND OBSERVATIONS

Type	Resistance Distance (cm)	Resistance Force (N)	Effort Force (N)	Effort Distance (cm)
Single Pulley				
Block and Tackle				

Questions and Conclusions

1. Work is calculated in joules (J) by multiplying force in newtons (N) and distance in meters (m). Be sure to convert distance values from centimeters to meters. *Work input* is the work done by you. Work input can be calculated by using the following equation.

$$\text{Work input (J)} = \text{Effort force (N)} \times \text{Effort distance (m)}$$

Your work input for the single pulley is:

Your work input for the block and tackle is:

Work output is the work done by the pulley. Work output can be calculated by using the following equation.

$$\text{Work output (J)} = \text{Resistance force (N)} \times \text{Resistance distance (m)}$$

Your work output for the single pulley is:

Your work output for the block and tackle is:

2. The *efficiency* of a machine is a measure of how work output compares with work input. The efficiency can be calculated by using the following equation.

$$\text{Efficiency} = \frac{\text{Work output}}{\text{Work input}}$$

Efficiency of the single pulley is:

Efficiency of the block and tackle is:

3. Why is the efficiency of the single pulley less than the efficiency of the block and tackle?