# Physics Workshop Teacher's Notes

## Pulleys and Pulley Systems

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|---|---|
| **Main Topic** | Forces |
| **Subtopic** | Simple Machines |
| **Learning Level** | Middle |
| **Technology Level** | Low |
| **Activity Type** | Student |

Description: Investigate fixed and movable pulleys, and how they work together in a pulley system.

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| Required Equipment | Workshop Stand, Pulleys, Bolt, Pulley String, Pinch Marker, 500g Hooked Mass, 500g Spring Scale, 100g Spring Scale, Meterstick. |
| Optional Equipment | |

## Educational Objectives

- Investigate fixed and movable pulleys, and how they work together in a pulley system.

## Concept Overview

Students will first investigate how a single fixed pulley can change the direction, but not the magnitude, of a force. They will then see how a single movable pulley can multiply, but not change the direction of, a force.

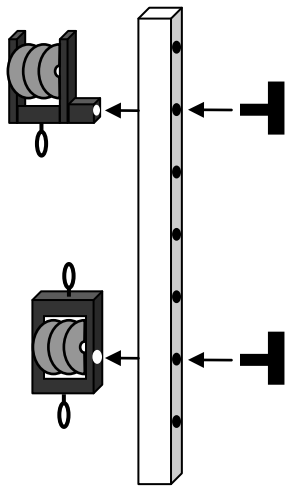
In the second activity, students will combine the fixed and movable pulleys into a simple system and investigate its effect on an applied force.

## Lab Tips

Students will assemble their own pulley systems in these labs. Below are instructions for the most complex assembly possible with these systems.

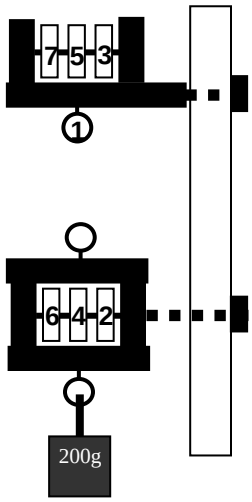
**Assembly:**

1. Push the attachment bolt through the Workshop Stand at approximately eye level.
2. Screw the bolt into the side of each pulley, as shown in the diagram.
3. Make sure that the bolts are tight, so that the pulley frames do not rotate. (*Note: The lower pulley is attached to the stand only for convenience during stringing. It will be detached after being strung in a pulley system.)*



## Pulleys and Pulley Systems

4. Students will use each pulley singly, as fixed and floating pulleys, then together in a pulley system (block-and-tackle). To string the pulley system:
    a. Hang a hooked mass from the lower pulley, to prevent its frame from rotating once detached from the stand.
    b. Use a length of string 7-8 times the distance between the two attached pulleys (or longer).
    c. Tie or clip one end of the string to the lower hook (1) on the upper pulley.
    d. It is important to keep the string taut through the stringing process, or it will slip off the wheels and be difficult to manipulate.
    e. Pass the string through the lower pulley, under the right-side wheel (2).
    f. Pass the string over the right-side wheel on the upper pulley (3).
    g. Repeat: lower (4), upper (5), lower (6), upper (7). See the numbered diagram for reference.
    h. The last string will come down over the upper pulley. This will be the string on which you pull. Until you are ready to begin the experiment, wrap this string around one of the bolts in the Workshop Stand.
    i. Hold the lower pulley in one hand while you detach the bolt. The lower pulley will now be supported by the strings alone.
    j. Tip: During the experiment, keep the free end wrapped on the stand base so the pulleys will not easily unstring.



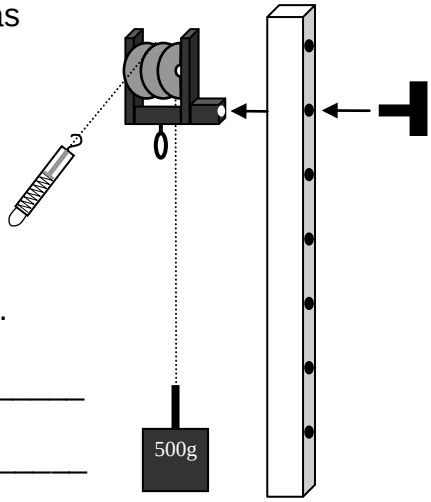
# Pulleys: Fixed and Movable Pulleys

**Objective**: To investigate the use of a fixed pulley.

**Materials**: Workshop Stand, Pulleys, Bolt, Pulley String, Pinch Marker, 500g Hooked Mass, 500g Spring Scale, Meterstick.

**Procedure**:

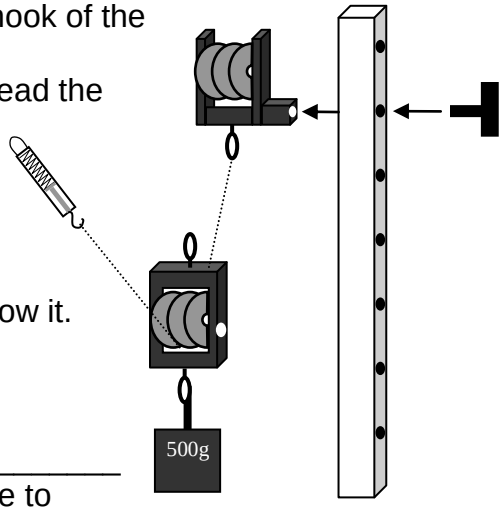
## I. Fixed Pulley




1. Attach the open pulley to the Workshop Stand as shown.
2. Tie or clip one end of the string to a 500g mass. Place the mass directly under the pulley.
3. Lay the string over the center wheel of the pulley.
4. Slide the pinch marker very close to the pulley, on the free end of the string.
5. Hook the spring scale through the pinch marker.
6. Pull on the string and lift the mass.
7. What direction does the mass move? _____
   This is the direction of the Output Force.
8. What direction do you pull? _____
   This is the direction of the Input Force.
9. What is the size of the Output Force? _____
10. What is the size of the Input Force? _____
11. Can a fixed pulley change the direction of a force? _____
12. Can a fixed pulley change the size of a force? _____
13. The Ideal Mechanical Advantage is equal to the number of strings supporting the weight. (Do <u>not</u> count any strings you pull <u>down</u> on.) What is the IMA of a fixed pulley? _____
14. How does the Mechanical Advantage describe the relationship between the Input and Output Forces?

## II. Movable Pulley

15. Remove the string from the pulley and mass. Tie or clip the end of the string to the hook under the fixed pulley. (The pulley merely serves as a support in this experiment.)
16. Measure and record the mass of the closed pulley. _____
17. Hang the 500g hooked mass from the lower hook of the closed pulley (as shown).
18. While one person holds the pulley steady, thread the string under the center wheel.
19. Release the pulley. It should rest on the string like a tightrope bicyclist.
20. Clip, tie, or loop the 500g spring scale to the free end of the string.
21. Hold the scale so that the mass is directly below it. Pull up on the spring scale.
22. What is the direction of the Output Force? _____
23. What is the direction of the Input Force? _____
24. What is the size of the Output Force? (Be sure to include the mass of everything that moves when you pull.) _____
25. What is the size of the Input Force? _____
26. Can a movable pulley change the direction of a force? _____
27. Can a movable pulley change the size of a force? _____
28. The Ideal Mechanical Advantage is equal to the number of strings supporting the weight. (Do <u>not</u> count any strings you pull <u>down</u> on.) What is the IMA of a movable pulley? _____
29. How does the Mechanical Advantage describe the relationship between the Input and Output Forces?




**Questions:**

1. Which type of lever (first-, second-, or third-class) most closely resembles a fixed pulley? Think about the directions of the Input and Output Forces, and their locations in relationship to the "fulcrum." Explain your answer with a statement or diagram.

2. Which type of lever most closely resembles a movable pulley? Explain your answer with a statement or diagram.

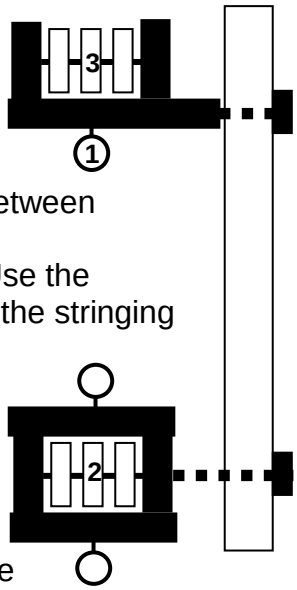
Name: _____
_____

# Pulleys: Pulley System

**Objective**: To investigate systems of fixed and movable pulleys working together.

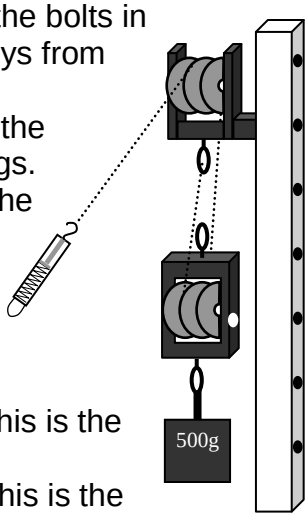
**Materials**: Workshop Stand, Pulleys, Bolts, Pulley String, Pinch Markers, 500g Hooked Mass, 500g Spring Scale, 100g Spring Scale, Meterstick.

**Procedure**:




**Assembly**

1. Measure and record the mass of the closed (lower) pulley. _____
2. Use a length of string approximately 4-5 times the distance between the pulleys.
3. Assemble a single-pulley system as shown in the diagram. Use the numbers as a guide for stringing. Keep the string taut during the stringing process.
    a. Bolt both pulleys to the stand, at least 30cm apart. (You will detach the lower, movable one later.) Hang a 500g mass from the lower pulley.
    b. Tie or clip the string to the hook under the upper pulley.
    c. Thread the string through the lower pulley, using the center wheel.
    d. Pass the string over the top pulley, using the center wheel.
    e. Wrap the free end of the string around one of the bolts in the Workshop Stand. This will keep your pulleys from unstringing.
    f. Hold the lower pulley steady while you detach the bolt. It will then be supported only by the strings.
4. Slide two pinch markers up next to the upper pulley, on the free end of the string. Hook the 500g spring scale through the outer pinch marker.




**Force, Direction, and Mechanical Advantage**

5. Pull on the string and lift the mass.
6. What direction does the mass move? _____ This is the direction of the Output Force.
7. What direction do you pull? _____ This is the direction of the Input Force.
8. What is the size of the Output Force? (Be sure to include everything that moves when you pull.) _____

9. What is the size of the Input Force? _____
10. Does this pulley system change the direction of a force? _____
11. Does this pulley system change the size of a force? _____
12. The Ideal Mechanical Advantage is equal to the number of strings supporting the weight. (Do not count any strings you pull down on.) What is the IMA of this system? _____
13. How does the Mechanical Advantage describe the relationship between the Input and Output Forces in this system?

    _____
    _____

**Distance and Mechanical Advantage**

14. Release the string so that the two pinch markers are near the top pulley. Remove the spring scale.
15. Use a meterstick to record the initial height of the bottom of the 500g mass. _____
16. Pull the string until the mass has risen 20cm. This is the Output Distance.
17. Hold the string in this position, and slide the upper pinch marker up next to the upper pulley. Measure the length of string between the two markers. _____ This is the distance you pulled, or the Input Distance.
18. Compare the Input and Output Distances.

    _____
    _____
19. How does the Mechanical Advantage describe the relationship between the Input and Output Distances in this system?

    _____
    _____

**Questions**

1. What are the advantages and disadvantages of pulley systems, in terms of what you put in and what you get out?

2. How could you change this system, using the same equipment, to use less force to lift the same mass?