VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE
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PULLEYS

7th grade version 2010

Goal: To understand of pulleys and how they are used to lift objects
To understand the mechanical advantage of different pulley systems

Lesson Outline:

I. Introduction
Discuss the six classes of simple machines.

II. Tug of War Demonstration
This demonstration will be a good introduction of mechanical advantage and the tradeoff between distance object moves and the amount of force needed to move the object.

III. Examining Materials and Using a Spring Balance
Have students practice using the spring balance with the 200-gram weight.

IV. Single Fixed Pulley
Measure the force needed to lift a weight with a single fixed pulley. Students follow diagrams as VSVS volunteer demonstrates. Discuss results, including mechanical advantage and the system's usefulness.

V. Single Movable Pulley
Measure the force needed to lift a weight with a single movable pulley. Students follow diagrams as VSVS volunteer demonstrates. Discuss results, including mechanical advantage and the system's usefulness.

VI. Single Fixed Pulley with Single Movable Pulley
Measure the force needed to lift a weight with a single fixed pulley and a single movable pulley system. Students follow diagrams as VSVS volunteer demonstrates. Discuss the results and the reason for using this pulley system.

VII. Double Fixed Pulley with Single Movable Pulley
Measure the force needed to lift a weight with a double fixed pulley and single movable pulley system. Students follow diagrams as VSVS volunteer demonstrates. Make sure the system is used correctly. Discuss results, including mechanical advantage and the system's usefulness.

VIII. Review
Review mechanical advantage and the data entries on the observation sheet. Connect the different experiments with the goals of the lesson.

IX. Optional Pulley Activities
Demonstrate the double fixed pulley with the double movable pulley and the triple fixed pulley combined with the double movable pulley.

Materials:

6 pulley stands with a short string attached to ring A and a long string attached to ring C (Each of these strings has a paper clip on the loose end.)
2 pieces of PVC pipe - For Part I Demonstration
1 rope - For Part I Demonstration
1 pair of gloves - For Part I Demonstration
6 large ziploc bags containing:
- 1 200g spring balance
- 1 200g weight
- 2 single pulleys
- 1 double pulley
- 1 short string with paper clips on both ends (wound around a straw)
- 1 long string with paper clips on both ends (wound around a straw)

1 ziploc bag containing:
- 1 triple pulley
- 1 long string with paper clips on both ends (wound around a straw)
- 1 calculator

30 pulley data sheets
15 sets of Pulley System Diagrams (laminated and on a ring) - one set for VSVS volunteers
30 optional activity worksheets

Management Notes:
The class should be divided into **6 groups of 4** students. (Groups must have at least 4 students.) If the class has less than 24 students, use fewer than six groups. Have the teacher assist in organizing the students into groups or request that the teacher group the students prior to your arrival.
All VSVS volunteers need to know how to do this experiment. Study the diagrams carefully as you are reading through the lesson.
Student groups will need close supervision during these activities. The materials may be difficult for some students to manipulate and some groups may have difficulty following the diagrams and instructions for each pulley system**. VSVS members should each supervise one or two groups of students to ensure that the groups are following instructions and using materials properly to achieve appropriate results.** This monitoring by VSVS members will also keep students focused on the activities and should minimize behavior problems. If needed, the teacher should be asked to help with the groups.

I. Introduction

- Ask students to name the six classes of simple machines. *Inclined plane, wedge, screw, lever wheel and axle/pulley*
- Ask students why we use machines. *to make work easier*
- Ask students to tell what they know about pulleys.
- Include the following in the discussion:
  - Pulleys are simple machines that are used in different ways to lift objects.
  - A string, rope, belt or chain passing around a wheel is the simplest pulley.

- Pulleys can change the direction of a force and can make it easier to lift heavy objects.
- A **single** pulley can either change the direction of a force or can make it easier to lift heavy objects. A **single** pulley cannot do both at the same time, whereas combinations of pulleys can.
- A **fixed** pulley is attached to a support and does not move. (Show fixed pulley)
- A **movable** pulley is attached to the object and moves along with the object.

- Ask students to name some examples or uses of pulleys. *Flagpole, hoisting sails, traction of broken bones of hospital patients, mini-blinds on windows, stage curtains, pulling cable cars, cranes, and others*

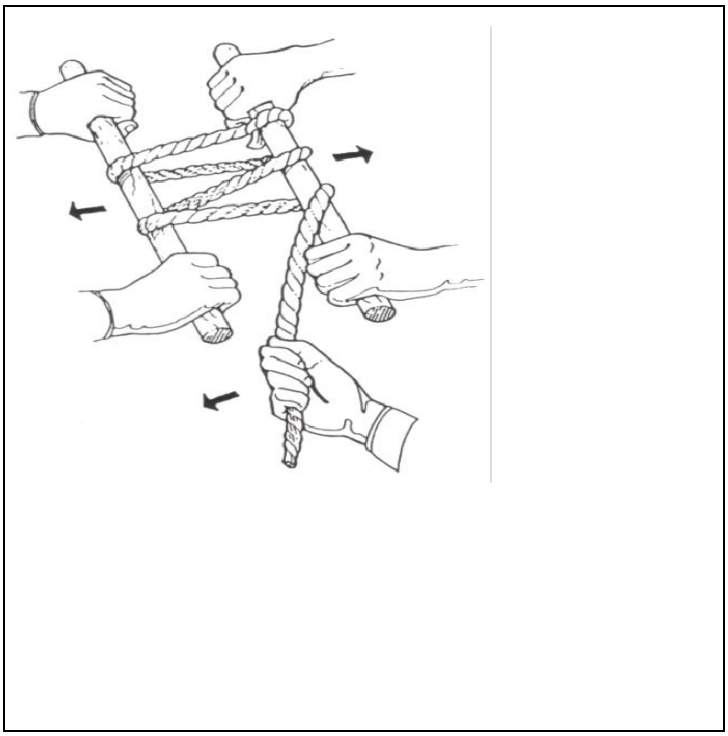
II. Tug of War: Demonstration

Materials:

2 PVC pipes
1 Rope
1 Pair of Gloves

Note: This demonstration is a good introduction to mechanical advantage and the trade off between the distance an object moves and the amount of force needed to move it.

- Arrange the PVC pipes as shown in the diagram and tie the rope to one and wind it around the pipes several times.
- Pick one of the smaller students to pull the rope using the gloves.
- Two VSVS members or teachers, each holding one of the PVC pipes and pulling in opposite directions, try to separate the pipes.
- At the same time the student volunteer, standing along side one of the VSVS members or teacher, and gripping the free end of the rope with both hands, pulls on the rope in an attempt to draw the pipes closer together. (The student is easily able to prevent the VSVS members or teachers from pulling the pipes apart.)
- Unwind the rope until it is only around the pipes once. Then ask the student volunteer to try again. (This time the student volunteer will not be able to prevent the VSVS members or teachers from separating the pipes.)
- If you have time, try winding the rope around the PVC pipes, one wind at a time, to demonstrate how it becomes easier for the student volunteer with each wind of the rope.



- Ask students why the volunteer was able to prevent the pipes from separating the first time and not the second time.
    - Point out that this is a pulley system – rope is used instead of string and pipes are used instead of pulley sheaves.
    - The mechanical advantage is increased or decreased by changing the number of turns of the rope around the PVC pipe (pulley).
    - The following experiments will reinforce mechanical advantage.

Note: VSVS volunteers should demonstrate all procedures in Parts I and II so the students will understand what to do. One person should call out instructions for each activity while others monitor the groups to ensure that students are following the diagrams and directions for all experiments.
Make sure that the students take turns manipulating the materials. The students who are manipulating the materials should face the side of the pulley system that has the letters A, B, and C above the rings.

III. Examining Materials and Using a Spring Balance

- Distribute to each group: 1 pulley stand, 1 large ziploc bag, 2 pulley data sheets, and 2 sets of diagrams of pulley systems. The extra sets of diagrams and calculator are for the instructors.
- Have students place the pulley stands near the edge of the table (lettered side facing the edge).

- Have students unpack the group bag and lay out the materials with the pulleys together, the 200g weight sitting with recessed end down and hook up, two strings (one long and one short, wrapped around straws), one spring balance and one calculator.

Note: A VSVS volunteer should hold up the components to make sure students understand the different types of pulleys - single pulley, double pulley. The weight needs to sit flat on the recessed end with the hook up.

- Have students in each group examine the spring balance.
- Have students arrange the handle so it hangs properly (some handles may have slipped).
- Instruct students to hold the spring balance by the handle**.**
- Notice that the spring balance goes from 0 to 200g and that the zero needs to be checked and possible adjusted.
- Show students how to adjust the zero by gently pulling the metal tab up to move the numbers up and by gently pushing the metal tab down to move the numbers down.
- Tell students that the metal tab should always start out even with the 0 mark.
- Tell students that they must "zero the balance" each time they measure.
- Check to make sure student groups do this correctly. Some students may need to learn how to read the increments of the scale on the spring balance.

Weighing with the Spring Balance

- Have students hold the spring balance by the top metal ring.
- Practice weighing the 200g weight by itself by hooking the spring balance to the hook on the weight and carefully raising the spring balance until the 200g weight is hanging freely (about one inch or 2.5 cm off the table). Keep arm still to get a good reading.
- Record the reading of the weight in the Mass of Object (load) column on the pulley Data Sheet. (If student readings are less than 200g, ask them to round up to 200g for this column.)
- Every student should have an opportunity to use the spring balance to weigh the 200g weight.
- Readings by different group members should be very close to 200g. If the readings are not close to 200g, the group should recheck the zero and repeat the exercise. It is important to keep your arm still to get an accurate measurement; otherwise the tab will go below 200g.

IV. Single Fixed Pulley: Measuring the effort required to lift a weight with a single fixed pulley.

Materials:

1 Single pulley
1 Short string (wound around straw)

- Make sure that the students have placed the pulley stand near the edge of the table with the lettered side facing the students who will be stringing the pulley.

- Have students follow the diagram for the **Single Fixed Pulley** as a teacher gives the following instructions.
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1. Place a single pulley on the middle ring (B) of the stand. Place the weight on the #1 written on the base of the stand.

2. Take the short loose string off the straw. Thread the string over the top of the pulley and gently pull down on the strings (grasp one in each hand just above the paperclips) to keep the string in the groove of the pulley.

3. Hook the **left** paper clip to the weight. Let go of the string on the left, but keep tension on the string on the right by pulling down gently.

4. Take the spring balance, check the zero, and **hold the balance upside down.** Hook the spring balance onto the **right** paper clip. (Be sure the spring is still in the groove of the pulley.) Pull the spring balance down gently until the weight lifts off the platform. Lift about 1" (2-3 cm). Keep the tension on the balance, and take a reading from the balance.

Tell the students to:

- Take the balance reading just as the weight moves off the platform, making sure there is still tension on the string.
- Record the reading in the "Balance Reading" column on the Single Fixed Pulley row of the Pulley Data Sheet. (The reading should be 200g, or very close.)
- Report your reading to the VSVS volunteer at the board. (6 readings will be noted.)

Calculations and Discussion of the Single Fixed Pulley

A. Mechanical Advantage

- Ask students if they can explain the term **mechanical advantage**.
- If students do not know about mechanical advantage, tell them that mechanical advantage is the force someone saves by using a machine.
- Keep this discussion brief and return to mechanical advantage later in the lesson. Hopefully, the explanation will become clearer as the lesson progresses.

VSVS Background Information: to be shared with the class as the lesson progresses:

Mechanical advantage tells you how much effort the user saves by using a machine. We can determine how helpful a machine is by determining how many times the machine multiplies our effort force (the effort we have to use) to overcome the resistance force (the object we have to move or the work we have to do). The more times a machine multiplies the effort force, the easier it is to do the job. There is a trade off, the effort is exerted over a greater distance, but less effort is required. After all, machines are only helpful if they make our work easier to do.

For example, a mechanical advantage of 2 multiplies our efforts twice which means that you only exert half the effort required to get the job done without the pulley (or a machine); a mechanical advantage of 3 multiplies your efforts three times which means you only exert one third of the effort to do the job, and a mechanical advantage of 4 multiplies your efforts by 4 which means you only exert one fourth of the effort.

Explain to the students that the mechanical advantage is shown by a number that represents the amount of reduction in force required to lift a given mass or the amount of force that is gained by using a machine. (The amount of advantage a person gains by using a machine.)

B. **Calculating the Average Balance Reading**

Refer to the six readings (one from each group) on the board.

- Ask students: How do you calculate an average of the numbers listed on the board?
    - If students do not know, explain that an average is calculated by adding up the total balance readings (six readings in most cases) and dividing the total by the number of readings (6 in most cases).
- Give the groups a few minutes to calculate the average balance reading, using their calculator.
- Then call on each group for their average and write it on the board.
- If there is any disagreement, point out the correct value and ask each group to record it on their data sheet in the Average Balance Readings column on the "Single Fixed" row of the Pulley Data Sheet.

C. Calculating the Mechanical Advantage

- Explain to students how to calculate the mechanical advantage.
- Explain that the mechanical advantage is calculated by dividing the mass of an object by the balance reading (effort) obtained when using a pulley system.
- Demonstrate this calculation by writing this example on the board:
    - Divide the resistance mass (200g; the mass of the object being lifted) by the average balance reading. In this case, 200g divided by 200g gives a mechanical advantage of one.
- Explain to students that a mechanical advantage of 1 means that we use the same amount of force to move the same amount of resistance.
- **We do not receive a mechanical advantage when we use a single fixed pulley or when the mechanical advantage is 1.**
- Ask students: Why would you use a single fixed pulley if there is no mechanical advantage?
    - It allows you to change the **direction** in which the effort is applied. For example: Running a flag up a flagpole uses a single fixed pulley at the top of the flagpole. You pull the rope down to make the flag go up.
    - The work output can never be greater than the work input if the effort force does not change. So the distance you pull is the same as the distance the object, the flag in this case, moves.
    - The pulley makes the job easier by taking an object spot that would be otherwise hard to reach.
- Ask students: How many sections of string were supporting the resistance weight? *only 1; the other section was being pulled in the opposite direction and does not count as a supporting string*.

- Tell students that you can tell how much a pulley system will reduce effort by counting the sections of the string that support the resistance (the weight or the load).
- You do not always count the "effort" string (the piece of string you are pulling on).
    - You only count the effort string when the effort exerted is in the same direction that the resistance is moved.
    - Since you pulled **down** on one piece of string in this experiment and the weight moved **up**, you do not count the effort string.
- The number of sections of string actually lifting the weight in this experiment would be one. (Have students look at the diagram to help them understand this. You might like to sketch one on the board if this is not clear to students.)
- Tell the students to dismantle the setup from section IV. Take off the pulley and the short loose string. Wind the string around the straw and put it back in the ziploc bag.

V. Single Moveable Pulley

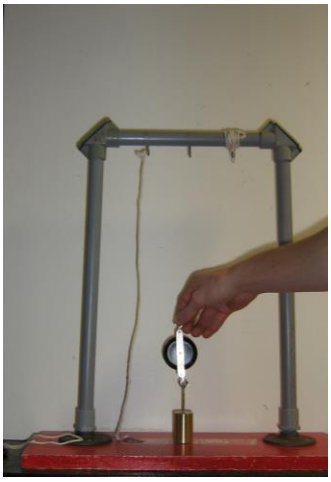
Materials: (already distributed in Section I)

1 Single pulley
1 Short string attached to the pulley stand at ring A

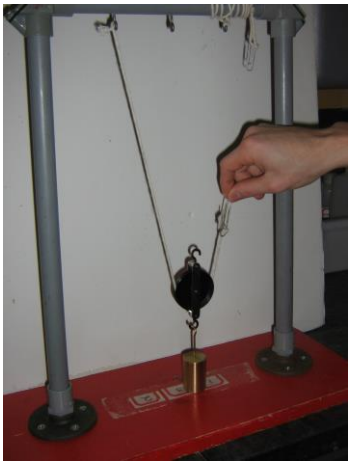
Have students follow the diagram for the **Single Movable Pulley**.
Demonstrate the following procedure to make sure students understand what they are going to do. After the demonstration, have students follow the procedure.

- Unwind the short string already attached to ring A on the pulley stand.
- Make sure that the students have placed the pulley stand near the edge of the table with the lettered side facing the students who will be stringing the pulley.

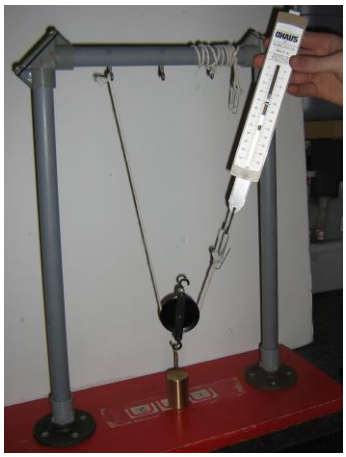
Warning: The movable pulley might twist around if the student is not holding it properly. Before they take a balance reading, students should make sure that neither the pulley not the string is twisted.



1. Place the weight on the #1 on the base of the stand. Hold the hook above the wheel on the single pulley and hook its bottom hook to the weight.
One student should continue to hold the pulley through diagram #3.



2. Thread the short string attached at "A" through the bottom of the pulley (from left to right), and slip it in the groove of the pulley.
Grasp the paper clip and hold it up toward the top of the stand. Make sure that the string is in the groove of the pulley.



3. Hold the balance upright and check the zero.
Attach the spring balance to the paper clip that is being held up in the air.
Let go of the pulley.
Slowly raise the balance until the weight is about 1" (2-3 cm) above the base of the stand.
Take a reading from the balance.

Tell the students to:

- Record the reading in the Group Balance Reading column on the "Single Movable" row of the Pulley Data Sheet. (This reading should be approximately 120g.)
- Each group should report its reading to the VSVS volunteer who will write the six readings on the board.
- Refer to the six readings (one from each group) on the board. If any reading is more than 15g from 120g, ask that group to take another reading.
- Rewind the short string around the bar near ring A.

Calculations and Discussion for the Single Moveable Pulley:

1. Write the six balance readings on the board.
2. Guide the groups as they calculate both the average class reading and the mechanical advantage. Each group should record the answers on the data sheet.
3. Write the six values calculated for mechanical advantage on the board.
    a. Values for the mechanical advantage of 1.8-1.9 should be 2.0 because the weight of the movable pulley contributes to the reading. Ask students to round the answer to the nearest whole number.
4. Ask students what it means if there is a mechanical advantage of 2.
    a. A movable pulley multiplies the effort force by 2. Therefore, you only have to exert half the force to do the same work. You must, however, exert that force for a greater distance. You pull twice as far, but you do not have to pull as hard.
5. Ask students to look at the diagram or the setup and count the sections of string that are supporting the weight in this experiment. Remind them to count the effort string (the section they are pulling) if that piece of string is being pulled in the same direction that the weight is moving.
6. This time you count the effort string because it is being pulled in the same direction that the weight is moving - the effort string is going up and the weight is going up so the effort string counts in this case.
7. Ask students if they notice any connection between the mechanical advantage and the numbers of sections of string that support the weight. They appear to be the

same. 1 piece of string bearing the weight = Mechanical Advantage of 1; 2 pieces of string bearing the weight = Mechanical Advantage of 2.

VI. Single Fixed Pulley with a Single Moveable Pulley

Materials: (already distributed in Section I)

2 Single pulleys

1 Long string attached to the pulley stand at ring C

- Guide student groups through the following procedure. Instruct students to follow the diagram for a **Single Fixed Pulley with a Single Movable Pulley** as you give instructions.
- Ask students to look at the last diagram for the Single Fixed Pulley with Single Movable Pulley and predict the mechanical advantage of this pulley system.
- Accept logical answers and ask students why they made that prediction. Have groups write their predictions in the margin outside the proper section of the data sheet.
- Do not tell students the correct answer at this time. Tell them to compare the prediction with the answer at the end of this experiment.
  - The correct prediction is 2. Some students may predict 3 if they are confused about counting the effort string. It does not count this time because it is being pulled in the opposite direction of the movement of the weight.
- Unwind the long string near ring C.

1. Place the weight on the #2 stand on the base of the stand. Hook a single pulley to ring B on the stand. Grasp one of the hooks of the other single pulley and attach it to the weight. (One student should continue to hold it through Diagram #3.)

2. Take the long string attached to ring C on the stand and thread the string through the bottom of the lower pulley (right to left) and over the top of the fixed upper pulley (thread from left to right). Grasp the end of the paper clip and gently pull down so the string remains taut.

3. Let go of the pulley and make sure the strings are still in the grooves of the pulleys. Zero the spring balance. Hold the spring balance upside down and attach it to the paper clip at the end of the string. Gently pull down until the weight is about 1" (2-3 cm) above the base of the pulley. Take a reading from the spring balance.

- Groups should record the reading balance in the Balance Reading column of the data sheet. (The reading should be approximately 100g-110g.)
- Report the reading to the VSVS member at the board.

Calculations and Discussion of Single Fixed Pulley with Single Moveable Pulley

1. Write the six balance readings on the board.
2. Guide the groups as they calculate both the average class reading and the mechanical advantage and record them on the data sheet. (Circulate to assist groups with this process.)
3. Write the six values calculated for mechanical advantage on the board. (Values for mechanical advantage should range from 1.6-2.0 because the weight of the movable pulley contributes to the reading.) Ask students to round to the nearest whole number (2).
4. Ask students how these results compare with the first two experiments. (The single fixed pulley had a mechanical advantage of 1 in the first experiment. The single movable pulley had a mechanical advantage of 2 in the second experiment. Using both pulleys in this experiment you have a mechanical advantage of 2. This is the same advantage as the single movable pulley alone.)
5. Ask: Why would you use a single movable pulley and a single fixed pulley if the mechanical advantage is the same as just using the single movable pulley?
    a. Movable pulleys cannot change the direction of the effort force. A fixed pulley can change the direction.
    b. A greater mechanical advantage can be obtained by combining fixed and movable pulleys into one pulley system. As more pulleys are used, more sections of string are attached to the system and each section helps support the object. Therefore, less force is required to move the object and this increases the mechanical advantage.

6. Ask students to look at the last diagram or the setup and count the sections of string that are supporting the weight in this experiment. Remind them to count the effort string (the section they are pulling on) only if that piece of string is being pulled in the same direction that the weight is moving.
7. This time you do not count the effort string because it is being pulled in the opposite direction that the weight is moving - the effort string is going down and the weight is going up.
8. Dismantle the setup from Section VI. Wind the long string around the bar near ring C.

VII. Double Fixed Pulley with Single Moveable Pulley

Materials: (already distributed in Section I)

1 Double pulley
1 Single pulley
1 Long string with paper clips on both ends (wound on a straw)

Ask students to look at diagram 4 for the **Double Fixed Pulley with a Single Fixed Movable Pulley** and make a prediction about the mechanical advantage they will find using this pulley system.

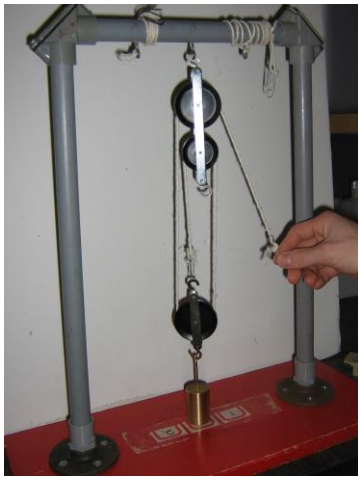
Accept predictions and ask why they made that prediction.

Instruct students to use the **long** string (the one wrapped around the straw) and follow the diagrams to arrive at a balance reading for this pulley system.

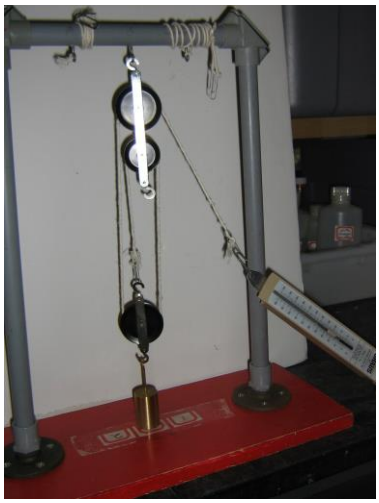
Unwind the long string from the straw.

1. Place the weight on the #3 on the base of the pulley stand. Hook the double pulley to ring B on the stand. Hold the top hook of the single pulley and attach the bottom hook to the weight. One student should continue to hold the pulley through diagram #3.

2. Take the long string (from the straw) and attach it to the hook at the top of the single pulley. Thread the string over the lower wheel on the double pulley (from left to right), then down under the single pulley (from right to left)



3. Thread the string over the top of the upper wheel on the double pulley (from left to right). Grasp the end of the paper clip and gently pull down so that the string remains taut.



4. Let go the pulley and make sure the strings are still in the grooves of the pulleys. Zero the spring balance. Hold the spring balance upside down and attach it to the paper clip at the end of the string. Gently pull down until the weight is about 1" (2-3 cm) above the base of the pulley. Take a reading from the spring balance.

- Record the reading in the Balance Reading column in the "Double Fixed with the Single Movable" row of the data sheet.
- Tell groups to record the balance reading on the data chart and report the results to the teacher at the board. (The balance reading should be approximately 65g - 70g).

Calculations and Discussion of Double Fixed Pulley and Single Moveable Pulley

1. Write the six balance readings on the board.
2. Guide the groups as they calculate both the average class reading and the mechanical advantage and record them on the data sheet.
3. Write the six values calculated for mechanical advantage on the board. (Values for the mechanical advantage should be approximately 3.)
4. Ask students why they think the mechanical advantage increased. *Adding the extra pulley and using more sections of string helped reduce the effort force and increase the mechanical advantage.*
5. Ask students to look at the last diagram or the setup and count the sections of string that are supporting the weight in this experiment. Remind them to count the effort string (the section they are pulling on) if that piece of string is being pulled in the same direction that the weight is moving.
6. This time you do not count the effort string because the effort string is being pulled in the opposite direction from the way the weight is moving - the effort string is going down and the weight is going up so the effort string does not count in this case.)

VIII. Results

- Discuss mechanical advantage and its relationship to the number of sections of string supporting the weight.
  - Mechanical advantage is equal to the number of sections of string supporting the weight in a pulley system.
- Explain to students, "you can't get something for nothing."
- Increasing the mechanical advantage requires that the force be moved through a longer distance. This lesson shows this characteristic by using long and short strings.
- Students should observe that the large mechanical advantage requires movement through a greater distance (use of the long string). In order to use less effort, you must pull the string through a greater distance.

Optional Activity

- Use the optional activity sheet and the triple pulley if there is time.
- Pass out the Pulley Optional Activity Sheet.
- Have students observe the diagrams and do the calculations
- Discuss the results.

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We gratefully acknowledge the assistance of Ann Orman, Metro Nashville Public Schools Science Teacher.

Pulley Data Sheet

Answer Key

PULLEY SYSTEM	MASS OF OBJECT (LOAD)	BALANCE READING (EFFORT)	AVERAGE BALANCE READING	ALLOWS CHANGE OF DIRECTION	SECTIONS OF STRING HOLDING WEIGHT	MECHANICAL ADVANTAGE
Single Fixed	**200g**	**200g**	**200g**	**yes**	**1**	**1**
Single Movable	**200g**	**110g**	**110g**	**no**	**2**	**2 - i.e., twice as easy**
Single Fixed with Single Movable	**200g**	**100g**	**100g**	**yes**	**2**	**2**
Double Fixed with Single Movable	**200g**	**65g**	**65g**	**yes**	**3**	**3 - i.e., three times as easy**

PULLEY DATA SHEET

PULLEY SYSTEM	MASS OF OBJECT (LOAD)	BALANCE READING (EFFORT)	AVERAGE BALANCE READING	ALLOWS CHANGE OF DIRECTION	SECTIONS OF STRING HOLDING WEIGHT	MECHANICAL ADVANTAGE
Single Fixed	**200 g**					
Single Movable	**200 g**					
Single Fixed with Single Movable	**200 g**					
Double Fixed with Single Movable	**200 g**					

Pulley Data Sheet 6/01

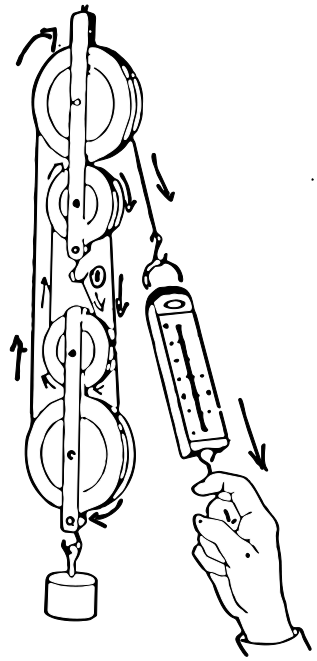
PULLEY DATA SHEET

PULLEY SYSTEM	MASS OF OBJECT (LOAD)	BALANCE READING (EFFORT)	AVERAGE BALANCE READING	ALLOWS CHANGE OF DIRECTION	SECTIONS OF STRING HOLDING WEIGHT	MECHANICAL ADVANTAGE
Single Fixed	**200 g**					
Single Movable	**200 g**					
Single Fixed with Single Movable	**200 g**					
Double Fixed with Single Movable	**200 g**					

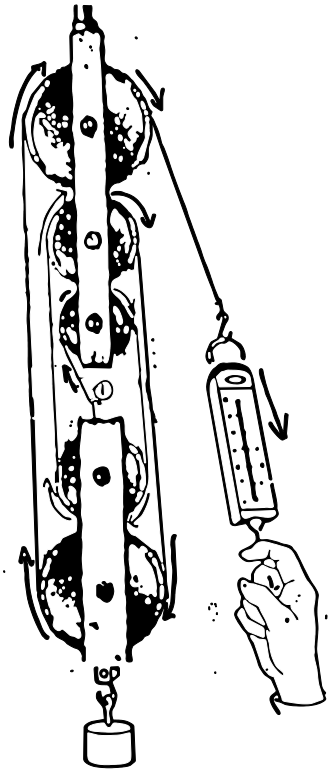
Pulley Data Sheet 6/01

PULLEY:: OPTIONAL ACTIVITY
Answer Sheet

DOUBLE FIXED PULLEY
and
DOUBLE MOVABLE PULLEY



TRIPLE FIXED PULLEY
and
DOUBLE MOVABLE PULLEY



Calculate the mechanical advantage (MA) of each system by counting the supporting strings. Count all strings supporting the weight. Count the string you pull on if it moves in the same direction that the weight moves.

Double Fixed Pulley and Double Movable Pulley MA 4

Triple Fixed Pulley and Double Movable Pulley MA 5

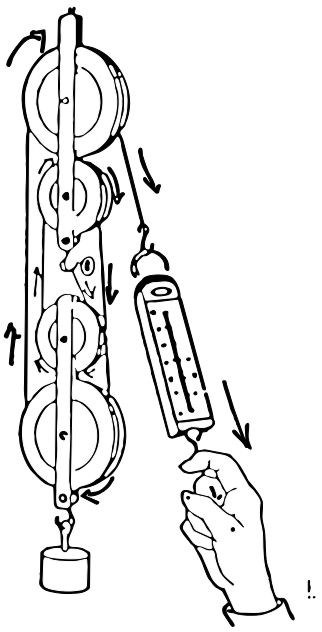
Calculate the amount of force (balance force) needed to lift a 200g weight. (200g divided by the mechanical advantage = amount of force.)

Double Fixed Pulley and Double Movable Pulley force 50

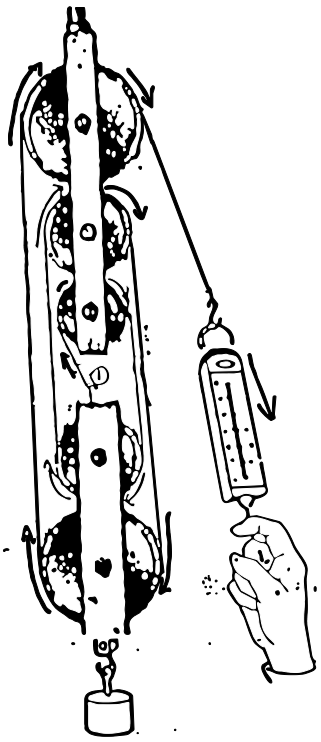
Triple Fixed Pulley and Double Movable Pulley force 40

PULLEY OPTIONAL ACTIVITY
Work Sheet

DOUBLE FIXED PULLEY
and
DOUBLE MOVABLE PULLEY



TRIPLE FIXED PULLEY
and
DOUBLE MOVABLE PULLEY



Calculate the mechanical advantage (MA) of each system by counting the supporting strings. Count all strings supporting the weight. Count the string you pull on if it moves in the same direction that the weight moves.

Double Fixed Pulley and Double Movable Pulley MA _____

Triple Fixed Pulley and Double Movable Pulley MA _____

Calculate the amount of force (balance force) needed to lift a 200g weight.
(200g divided by the mechanical advantage = amount of force.)

Double Fixed Pulley and Double Movable Pulley force _____

Triple Fixed Pulley and Double Movable Pulley force _____

Instruction Sheet

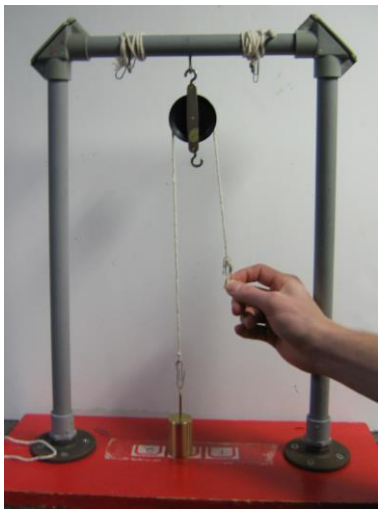
SINGLE FIXED PULLEY

Materials - short loose string (take off the straw). and single pulley

Make sure the pulley stand is placed near the edge of the table with the lettered side facing the students stringing the pulley.

1. Place a single pulley on the middle ring (B) of the stand. Place the weight on the #1 written on the base of the stand.

2. Take the short loose string off the straw. Thread the string over the top of the pulley and gently pull down on the strings (grasp one in each hand just above the paperclips) to keep the string in the groove of the pulley.



3. Hook the **left** paper clip to the weight. Let go of the string on the left, but keep tension on the string on the right by pulling down gently.

4. Take the spring balance, check the zero, and **hold the balance upside down.** Hook the spring balance onto the **right** paper clip. (Be sure the spring is still in the groove of the pulley.) Pull the spring balance down gently until the weight lifts off the platform. Lift about 1" (2-3 cm). Keep the tension on the balance, and take a reading from the balance.

<u>Take the balance reading just as the weight moves off the platform, making sure there is still tension on the string.</u>

- Record the reading in the second column (headed Group Balance Reading) on the Single Fixed Pulley row of the Pulley Data Sheet.

- Report your reading to the VSVS volunteer at the board.
- Take pulley off the hook and rewind the short loose string around the straw.

SINGLE MOVABLE PULLEY

Materials

single pulley, short string attached to the pulley stand at ring A

- Unwind the short string already attached to ring A on the pulley stand.
- Make sure the pulley stand is near the edge of the table with the lettered side facing the students who will be stringing the pulley.

Warning: On movable pulleys, the pulley might twist around if the student is not holding it properly. Before they take a balance reading, students should make sure that neither the pulley nor
the string is twisted.

1. Place the weight on the #1 on the base of the stand. Hold the hook above the wheel on the single pulley and hook its bottom hook to the weight. One student should continue to hold the pulley through diagram #3.

2. Thread the short string attached at "A" through the bottom of the pulley (from left to right), and slip it in the groove of the pulley. Grasp the paper clip and hold it up toward the top of the stand. Make sure that the string is in the groove of the pulley.

3. Hold the balance upright and check the zero. Attach the spring balance to the paper clip that is being held up in the air.
Let go of the pulley.
Slowly raise the balance until the weight is about 1" (2 -3 cm) above the base of the stand.
Take a reading from the balance.

- Record the reading in the Group Balance Reading column on the "Single Movable" row of the Pulley Data Sheet.
- Report the Balance Reading to the VSVS volunteer at the board.
- Rewind the short string around the bar near ring A.

SINGLE FIXED PULLEY WITH SINGLE MOVABLE PULLEY

Materials

2 single pulleys
1 long string attached to ring C

- Unwind the long string near ring C.
- Make sure the pulley stand is near the edge of the table with the lettered side facing the students who will be stringing the pulley.

1. Place the weight on the #2 on the base of the stand. Hook a single pulley to ring B on the stand. Grasp one of the hooks of the other single pulley and attach it to the weight. (One student should continue to hold it through Diagram #3.)

2. Take the long string attached to ring C on the stand and thread the string through the bottom of the lower pulley (right to left) and over the top of the fixed upper pulley (thread from left to right). Grasp the end of the paper clip and pull down gently so the string remains taut.

3. Let go of the pulley and make sure the strings are still in the grooves of the pulleys.
Zero the spring balance. Hold the spring balance upside down and attach it to the paper clip at the end of the string.
Gently pull down until the weight is about 1 inch (2-3 cm) above the base of the pulley.
Take a reading from the spring balance.

- Record the balance reading in the Group Balance Reading column of the Pulley Data Sheet.
- Report the reading to the VSVS volunteers at the board.

DOUBLE FIXED PULLEY WITH SINGLE MOVABLE PULLEY

MATERIALS

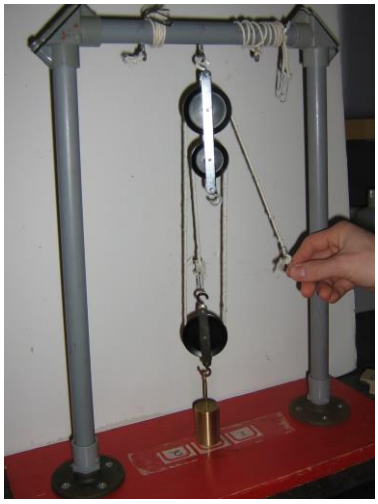
1 Double pulley
1 Single pulley
1 Long string with paper clips on both ends (wound on a straw)

- Look at the diagram for the **Double Fixed Pulley with a Single Fixed Movable Pulley** and make a prediction about the mechanical advantage you will find using this pulley system.
- Use the **long** string (the one wrapped around the straw) and follow the diagrams to arrive at a balance reading for this pulley system.
- Record the reading in the Balance Reading column in the "Double Fixed with the Single Movable" row of the data sheet.

1. Place the weight on the #3 on the base of the pulley stand. Hook the double pulley to ring B on the stand. Hold the top hook of the single pulley and attach the bottom hook to the weight. One student should continue to hold the pulley through diagram #3.

2. Take the long string (from the straw) and attach it to the hook at the top of the single pulley. Thread the string over the lower wheel on the double pulley (from left to right), then down under the single pulley (from right to left)

3. Thread the string over the top of the upper wheel on the double pulley (from left to right). Grasp the end of the paper clip and gently pull down so that the string remains taut.



4. Let go the pulley and make sure the strings are still in the grooves of the pulleys. Zero the spring balance. Hold the spring balance upside down and attach it to the paper clip at the end of the string. Gently pull down until the weight is about 1" (2-3 cm) above the base of the pulley. Take a reading from the spring balance.