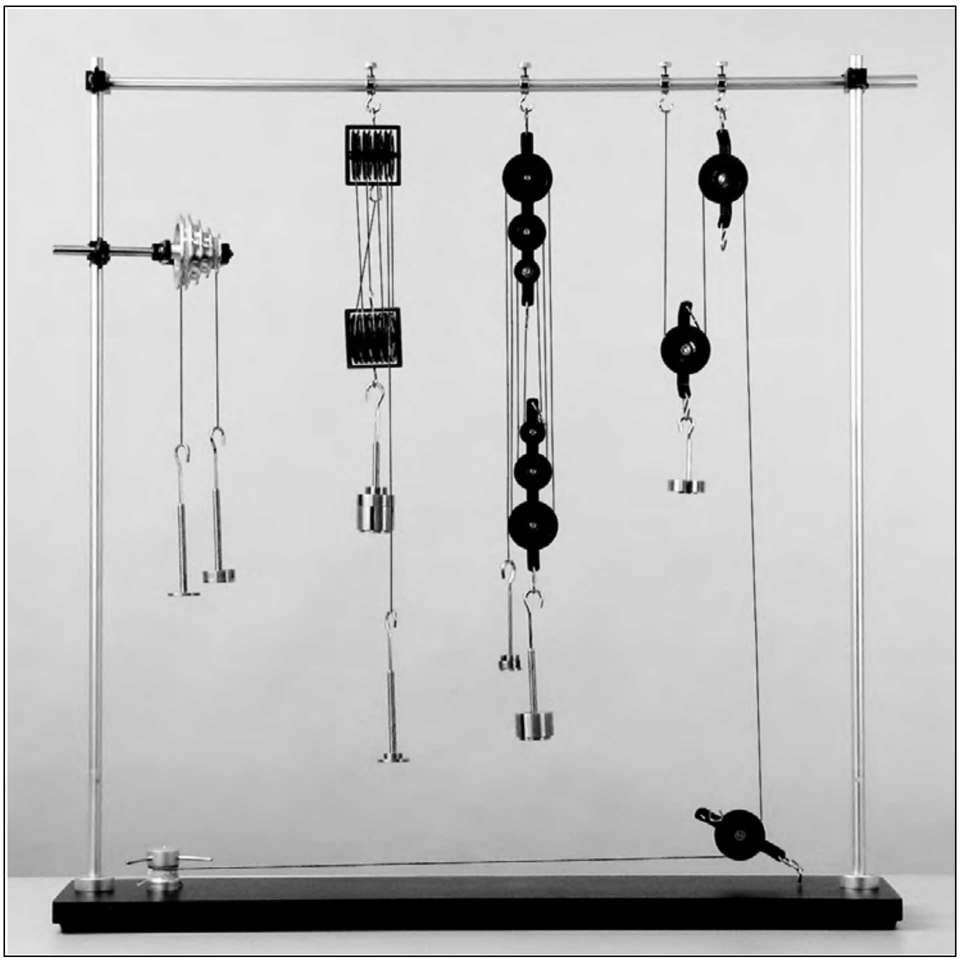
Instruction Manual

Manual No. 012-08546A

Pulley Demonstration System

Model No. SE-8685



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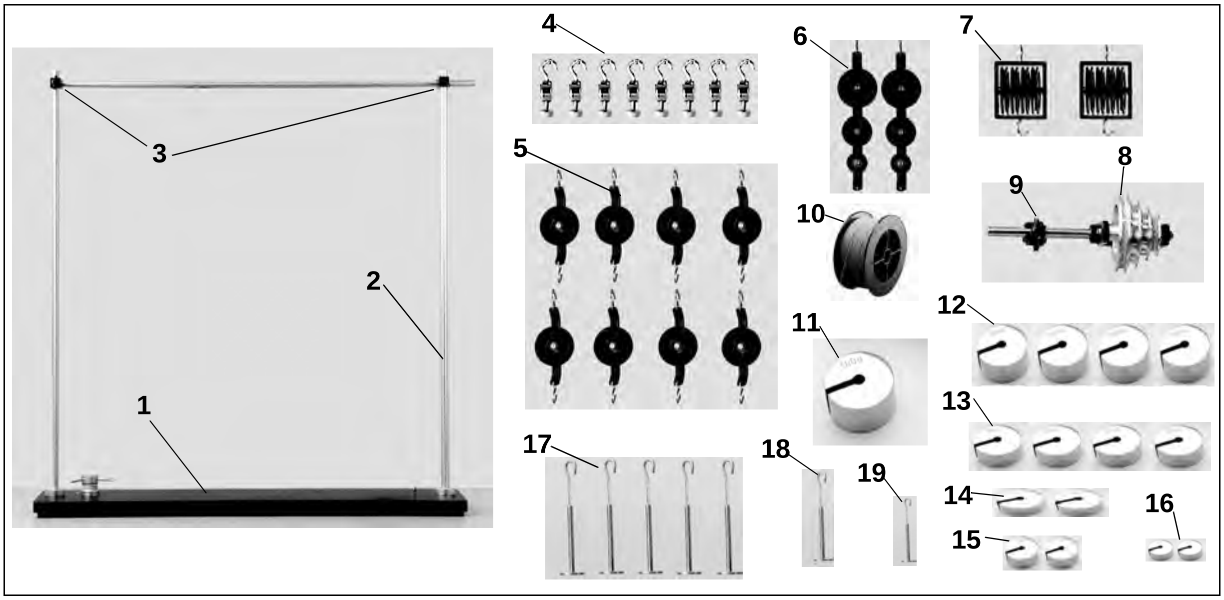


Included Equipment	
1. Base, 20 cm x 81 cm (1)	11. Slotted mass, 500 grams (1)
2. Aluminum rods, 81 cm (3)	12. Slotted mass, 200 grams (4)
3. Clamps, 90-degree angle (2)	13. Slotted mass, 100 grams (4)
4. Hook collars (8)	14. Slotted mass, 50 grams (2)
5. Single pulley (8)	15. Slotted mass, 20 grams (2)
6. Triple-tandem pulley (2)	16. Slotted mass, 10 grams (2)
7. Quadruple parallel pulley (2)	17. Slotted mass hanger, 50 grams (5)
8. Four-step differential pulley with head(1)	18. Slotted mass hanger, 20 grams (1)
9. Tightening rod (1)	19. Slotted mass hanger, 10 grams (1)
10. Nylon cord spool, 100 yards (1)	

Additional Equipment Required	Model Number
Metric Spring Scale, 20 N	SE-8718
Force Sensor	PS-2104* or CI-6746**
Rotary Motion Sensor	PS-2120* or CI-6538**
Any PASCO interface (*ScienceWorkshop*® or PASPORT™ interface)	Various (See PASCO catalog)
A computer	NA

* PASCO's PASPORT sensors (with PS- prefix) require a PASPORT interface for operation.

******PASCO's *ScienceWorkshop* sensors (with CI- prefix) require a *ScienceWorkshop* interface for operation.

Introduction

The Pulley Demonstration System (SE-8685) is designed for both the student and the teacher. Its ease of use is suited for students learning the basics of mechanical advantage with pulley applications. The various kinds of pulleys and accessories make it the ideal pulley demonstration tool.

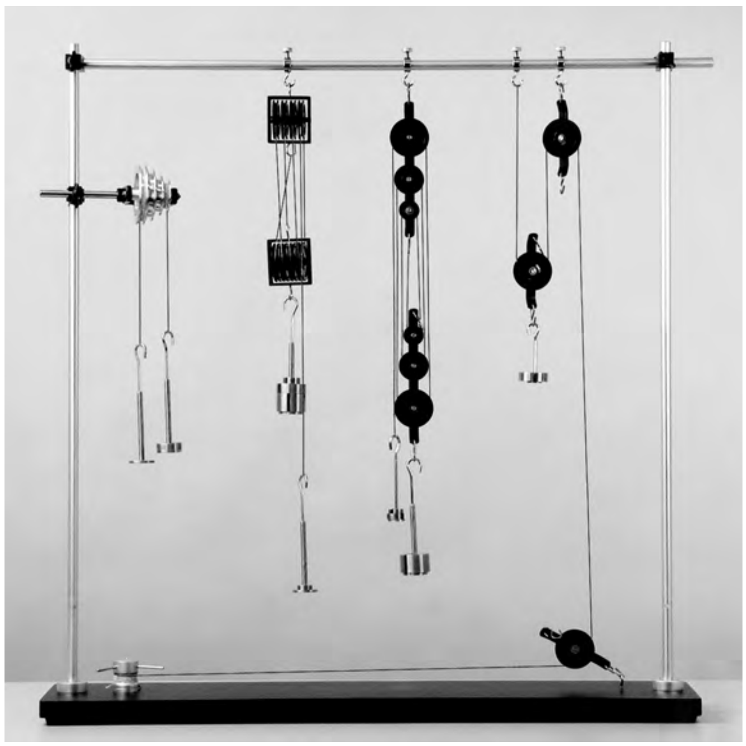


Figure 1: Pulley Demonstration System

PASCO offers a variety of sensors and equipment for measuring force, rotary motion, and work or energy. PASCO's Metric Spring Scales (SE-8713 to SE-8718) provide an economical way to instrument the Pulley Demonstration System for measurements of force. For real-time data collection, and more accuracy and precision, use PASCO's Force and Rotary Motion Sensors with a computer interface and the Pulley Demonstration System to demonstrate work/energy theory.

Equipment Setup

I. Assembling the Pulley Frame

a) Set the base on a sturdy, level surface. b) Thread the two support rods to the base. c) Fasten both clamps to the top of the support rods. d) Attach only one side of the horizontal rod to a clamp, so that one end is free and the other is fixed. e) Slide the hook collars down the free end of the horizontal rod. f) Secure the free end. g) Tighten the hook collars using the top screws.

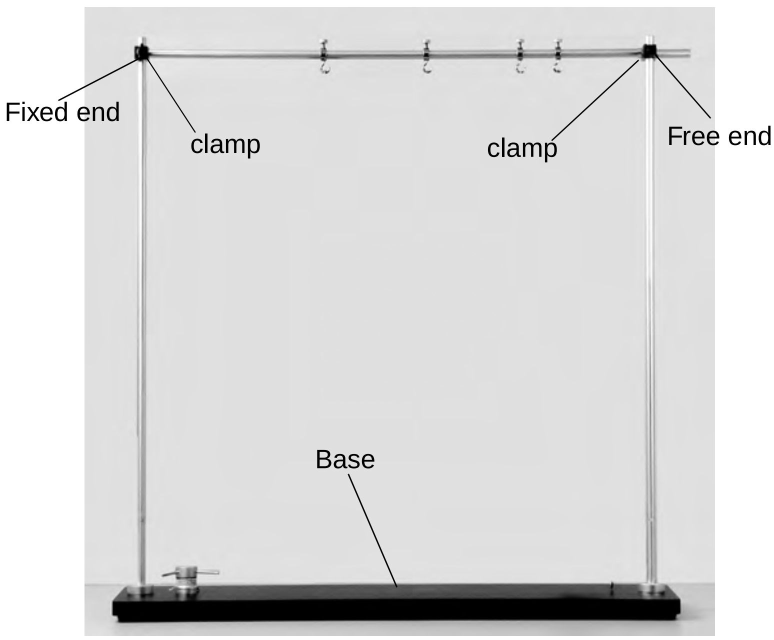


Figure 1: Assembled Frame

II.Sample Setup Options (Hanging Pulleys on the Frame

A. Set up a Single Pulley on the Frame

a) Hang the metal hook on the top of the single pulley on the hook collar. b) Tie string to a mass hanger and loop it up and around the pulley. c) Add weight to the mass hanger. [Note: The free end is for pulling and attaching measuring devices (i.e. spring scale or Force Sensor) to measure the force.]

Figure 2: Single Pulley

B. Set up a Double Pulley on the Frame

a) Hang a single pulley to a hook collar. b) Tie string to another hook collar. c) Loop the string underneath another single pulley. d) Attach a mass hanger to the lower pulley's lower hook. e) Loop the string up and over the top pulley.

[Note: The free end is for pulling and attaching measuring devices (i.e. spring scale or Force Sensor) to measure the force.]

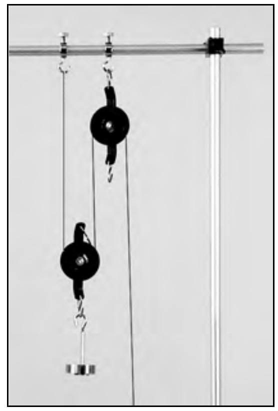


Figure 3: Double Pulley

C. Set up One or More Triple-Tandem Pulley(s) on the Frame

Set up for one triple-tandem pulley: a) Place a hook collar on the frame and adjust the top screw to tighten. b) Hang the upper metal hook of the triple-tandem pulley onto the hook collar. c) Loop a separate piece of string around each ring and hook to a mass hanger. d) Add mass. A variety of setups can be used, depending upon your experiment.

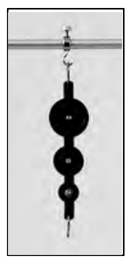


Figure 4a: One Triple-Tandem Pulley

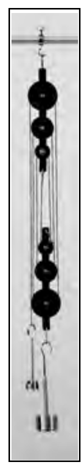


Figure 4b: Two Triple-Tandems

Setup for two triple-tandems together: a) Hang one triple-tandem on the frame and hold a second triple-tandem underneath. b) Loop the string on the lower hook of the upper pulley and continue to string in the following direction and sequence: i) down and around the smallest ring on the lower pulley, ii) up and around the smallest ring on the upper pulley, iii) down and around the medium ring on the lower pulley, iv) up and around the medium ring on the upper pulley, v) down and around the large ring on the lower pulley, vi) up and around the large ring on the upper pulley, vii) Attach a mass hanger to the string hanging from the upper pulley and add mass. viii) Hook a mass hanger to the lower pulley and add weight to balance.

D. Set up One or More Quadruple Pulley(s) on the Frame

Set up for one quadruple pulley: a) Attach a hook collar to the frame and tighten. b) Hang the quadruple pulley on the hook collar. c) Loop a separate piece of string around each ring and hook to a mass hanger. d) Add mass. e) Use the free end of the string for pulling or attaching measuring devices. (Note: A variety of setups can be used, depending upon your experiment.)

Figure 5a: Quadruple pulley

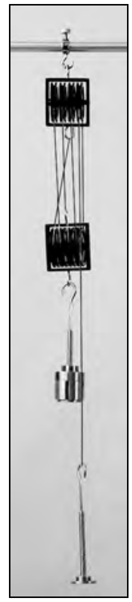


Figure 5b: Setup with two quadruple pulleys

Set up for two quadruple pulleys: For this setup, have a lab partner available to hold the lower pulley while you string the pulleys. To string, tie a knot on the hook of the upper pulley and string in the following direction and sequence (Note: Keep all strings parallel (not crossed):

i) around the outside rung of the lower pulley, ii) up and around the outside rung of the upper pulley, iii) down and around the third rung on the lower pulley, iv) up around the third rung on the upper pulley, v) down and around the second rung on the lower pulley, vi) up and around the second rung on the upper pulley, vii) down and around the inside rung on the lower pulley, viii) down and around the first rung on the upper pulley, viv) Hook string from the upper pulley to a mass hanger and add weight. x) Add weight to the lower pulley.

E. Set up a Four-Step Pulley on the Frame

a) Fasten the 90° clamp to a vertical rod. b) Attach the four-step pulley to the 90° clamp. c) String each rung separately. d) Add mass hangers and masses to balance.

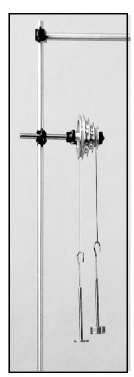


Figure 6a: Setup for a Four-Step Pulley

Suggested Experiments/Demonstrations

Experiment 1: Mechanical and Force Differences between a Single Pulley and Double Pulley

Equipment required (without computer):	Optional equipment (for use with computer interface):
Pulley Demonstration System (SE-8685)	Two Force Sensors (CI-6746) or (PS-2104)
Two Spring Scales (SE-8718)	Computer Interface (1 *ScienceWorkshop* or 1-2 PASPORT)*
Measuring tape (PM-8761)	DataStudio software

*PASCO's PASPORT sensors (with PS- prefix) require a PASPORT interface for operation. PASCO's *ScienceWorkshop* sensors (with CI- prefix) require a *ScienceWorkshop* interface for operation.

Basic Procedure:

1. Set up a double pulley and a single pulley each with a 200 g mass.

2. Simultaneously, pull the string of each from the same vertical height down to the base.

3. Observe that the mass of the single pulley rises twice as high as the double pulley with twice the effort or force.

4. Optional step: Measure the force of each pulley using either two Newton Spring scales or two Force Sensors (See descriptions a) and b) that follow).

Figure 1.1: Single pulley vs. double pulley

a) Measure the Pulley Force with the Newton Spring Scale

Attach Newton spring scales to the string on each pulley and quantitatively discover that the force exerted for the double pulley decreases by a factor of 2, while the amount of string that is pulled increases by the same factor. Prove that the number of pulleys relates to this factor. Show students that increasing the number of pulleys increases the mechanical advantage. Discuss the fact that the amount of work done is the same in either pulley.

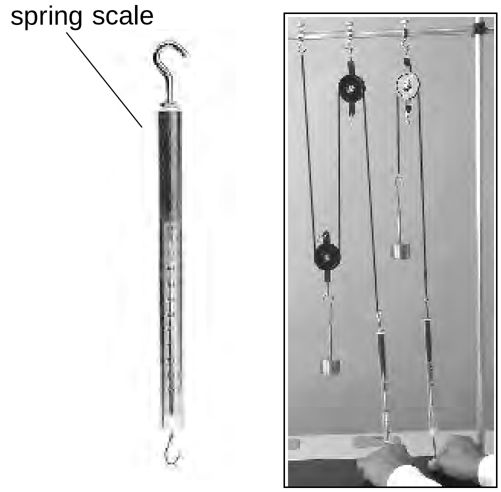


Figure 1.2: Measuring the force with spring scales

b) Measure the Pulley Force with a Force Sensor and a Computer Interface

Instead of Newton Spring Scales, use two PASCO Force Sensors to observe real-time force changes in DataStudio software.

1. Connect each Force Sensor to a computer interface (*ScienceWorkshop* or PASPORT).

Figure 1.3: Connecting the Force Sensor to a PASPORT interface and to a computer

2. Hang one Force Sensor from the single pulley and the other Force Sensor from the double pulley. (To hang, screw a hook to the top of the Force Sensor and tie the hanging string through the hook.)

3. In DataStudio, open a graph display and click the **Start** button to collect data. As you pull down on each pulley, force data for both pulleys will appear in the display.

Figure 1.4: Pulling on the Force Sensor

Experiment 2: Determining the Work/Energy of a Pulley System

Equipment required:	
Pulley Demonstration System (SE-8685)	Rotary Motion Sensor (CI-6538 or PS-2120)
Force Sensor (CI-6746 or PS-2104)	Computer Interface (1 *ScienceWorkshop* or 1-2 PASPORT)*
DataStudio software	

*PASCO's PASPORT sensors (with PS- prefix) require a PASPORT interface for operation. PASCO's *ScienceWorkshop* sensors (with CI- prefix) require a *ScienceWorkshop* interface for operation.

Students can quantitatively find the work done on a pulley system by using PASCO's Rotary Motion Sensor simultaneously with a Force Sensor.

1. Attach a hook collar and clamp a Rotary Motion Sensor to the horizontal rod.

2. Tie one end of string to the hook collar and loop the string underneath a pulley. Hang a mass from this pulley.

3. Loop the remaining string around the inside groove of the Rotary Motion Sensor.

4. Tie the other end of the string to the Force Sensor.

Figure 2.1

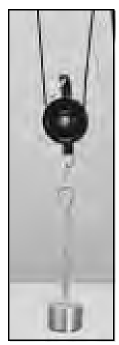


Figure 2.2

Figure 2.3

Figure 2.1-3: Setup for Experiment 2

5. In DataStudio, click the **Start** button and pull on the Force Sensor. The work done can be calculated by finding the area in a Force versus Position graph.

Note: To create a Force vs. Position graph: In DataStudio's Experiment Setup window, go to the Rotary Motion Sensor and click the Linear Position option. From the Data list, drag the position icon over the x-axis in the Graph display.

Alternatively, students can compare the work done on just one pulley. Hang the same mass from just the Rotary Motion Sensor. Pull the Force Sensor until the work done is the same as with two pulleys. Students will find that the force applied doubles while the distance pulled is decreased by half.

Experiment 3: Discovering the Mechanics of a Wheel and Axle (4-Step Pulley)

Equipment required:	
Pulley Demonstration System (SE-8685)	Calipers (SF-8711) or measuring tape (PM-8761)

1. Have students measure the diameters of the grooves of the pulley. (If calipers or a meauring tape is not available, see the Specifications in Appendix A.)

2. Loop string counterclockwise around the smallest groove of the 4-step pulley until there is enough friction for the string to support a large mass.

3. Choose one of the other grooves and loop enough string clockwise until it can support some mass.

4. Have the students experiment with the amount of mass that balances the system.

5. Ask students to calculate the ratio between the masses and compare this value to the ratio of the diameters of the grooves. Students should find that the ratio of the diameters of the grooves is identical to the ratio of the masses.

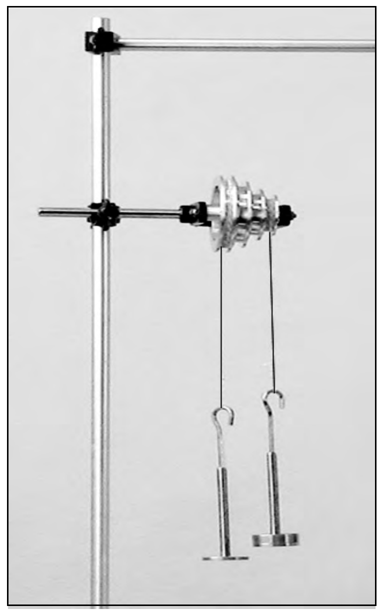
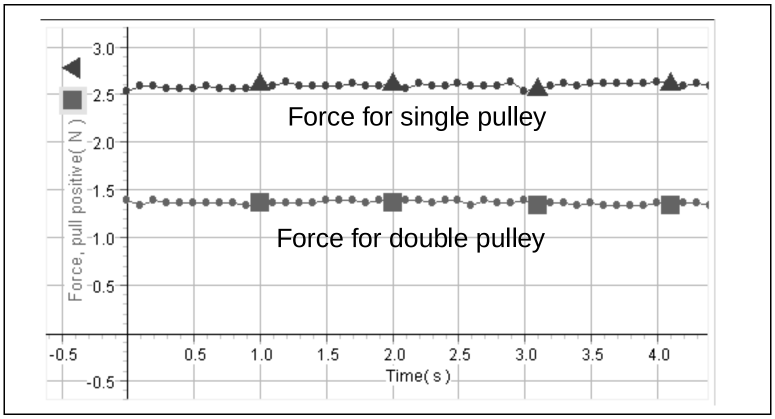


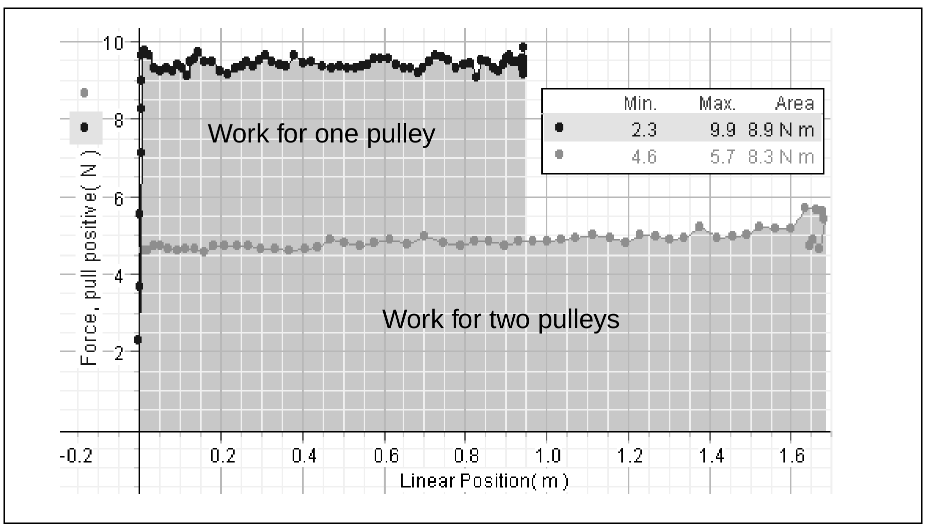
Figure 3: Setup with Wheel and Axle

Sample Data/Results

Experiment 1 Results: Mechanical Force Differences in Single Pulley vs. Double Pulley



Experiment 2 Results:Measuring the Work/Energy of a Pulley System



Experiment 3 Results: Discovering the Mechanics of a Wheel and Axle (4-Step Pulley)

Groove 1: diameter = 2.0 cm; mass = 10 g
Groove 4: diameter = 6.0 cm; mass = 30 g
Ratios: diameters=1/3; masses=1/3

Appendix A: Specifications

Pulleys	Specifications:
Single pulley:	circumference: 15.4 cm; diameter: 4.9 cm
Triple-tandem pulley:	small pulley: circumference: 7.9 cm ; diameter: 2.5 cm medium pulley: circumference: 11.6 cm; diameter: 3.7 cm large pulley: circumference: 15.4 cm; diameter: 4.9 cm
Quadruple pulley:	pulley circumference: 15.4 cm; diameter: 4.9 cm
Four-step pulley:	step 1 groove: 6.28 cm circumference; 2.0 cm diameter step 2 groove: 9.42 cm circumference; 3.0 cm diameter step 3 groove: 12.56 circumference; 4.0 cm diameter step 4 groove: 18.84 circumference: 6.0 cm diameter
Slotted masses:	10 g, 20 g, 50 g, 100 g, 200 g, 500 g

Appendix B: Technical Support

For assistance with the SE-8685 or any other PASCO products, contact PASCO as follows:

Address: PASCO scientific

10101 Foothills Blvd.

Roseville, CA 95747-7100

Phone: (916) 786-3800

FAX: (916) 786-3292

Web: www.pasco.com

Email: techsupp@pasco.com

Appendix C: Copyright and Warranty Information

Copyright Notice

Limited Warranty

PASCO scientific warrants the product to be free from defects in materials and workmanship for a period of one year from the date of shipment to the customer. PASCO will repair or replace, at its option, any part of the product which is deemed to be defective in material or workmanship. The warranty does not cover damage to the product caused by abuse or improper use. Determination of whether a product failure is the result of a manufacturing defect or improper use by the customer shall be made solely by PASCO scientific. Responsibility for the return of equipment for warranty repair belongs to the customer. Equipment must be properly packed to prevent damage and shipped postage or freight prepaid. (Damage caused by improper packing of the equipment for return shipment will not be covered by the warranty.) Shipping costs for returning the equipment after repair will be paid by PASCO scientific.