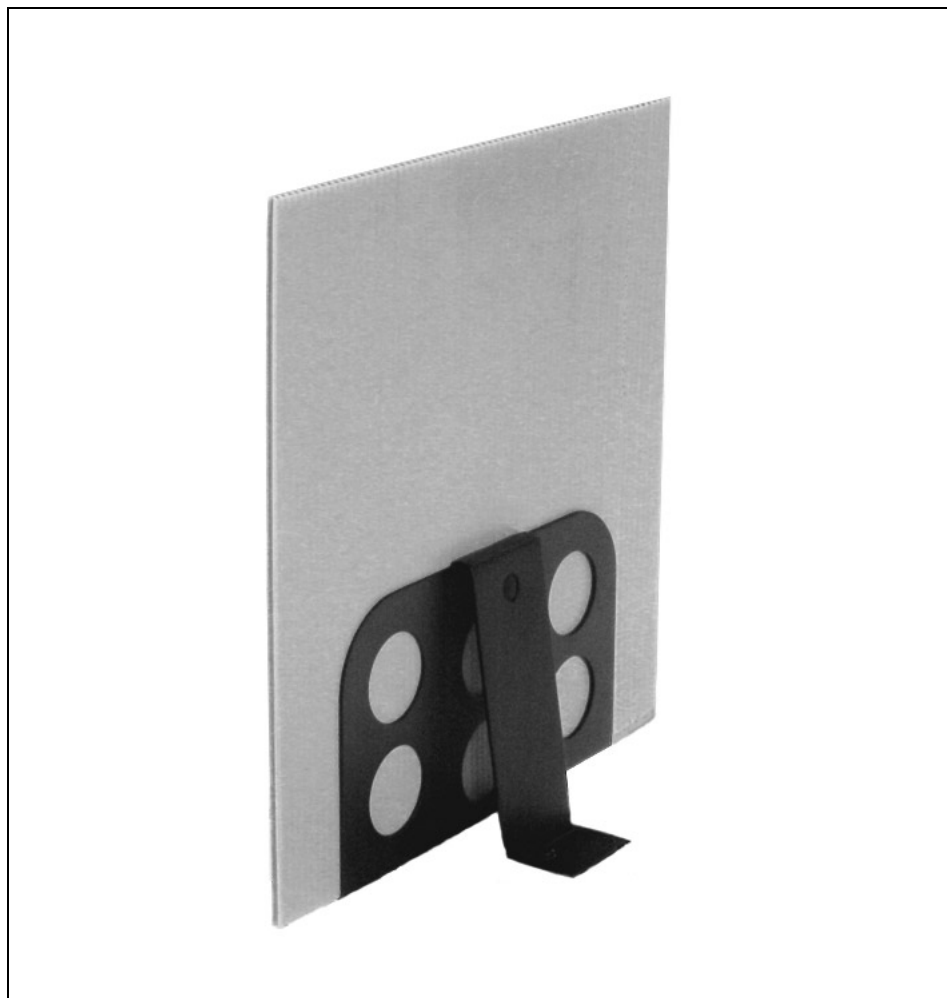




# Car Sail

Model No. ME-9595





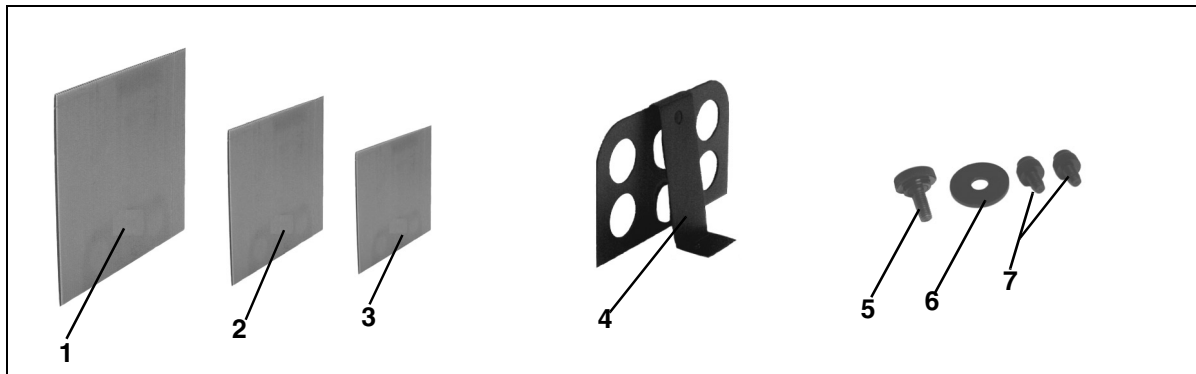
## Table of Contents

<b>Equipment List</b> .....	<b>3</b>
<b>Introduction</b> .....	<b>4</b>
<b>Equipment Setup</b> .....	<b>4</b>
<b>Suggested Experiments</b> .....	<b>5-8</b>
Experiment 1: Investigating Air Resistance.....	5-6
Experiment 2: Surface Area and Terminal Velocity.....	7-8
<b>Sample Data/Results</b> .....	<b>9</b>
<b>Appendix A: DataStudio Instructions</b> .....	<b>10</b>
<b>Appendix B: Technical Support</b> .....	<b>11</b>
<b>Appendix C: Copyright and Warranty Information</b> .....	<b>11</b>

# Car Sail

Model No. ME-9595

## Equipment List



Included Equipment	Replacement Model Number*
1. 3600 cm <sup>2</sup> Sail, mass=290 grams	648-08216
2. 1800 cm <sup>2</sup> Sail, mass=145 grams	648-08215
3. 900 cm <sup>2</sup> Sail, mass=73 grams	648-08214
4. Sail Bracket	648-08213
5. Thumbscrew (10-32x 1/2) for mounting sail to bracket	617-001
5. Washer for mounting screw to sail	615-107
6. Thumbscrews for mounting sail to cart (2)	613-075

\*Use Replacement Model Numbers to expedite replacement orders.

Additional Equipment Required (for experiments)	
Any PASCO data acquisition device ( <i>ScienceWorkshop</i> <sup>®</sup> or <i>PASPORT</i> <sup>™</sup> interface)	various (See PASCO catalog)
DataStudio <sup>®</sup> software	various (See PASCO catalog)
PAScar, GOcar, or Dynamics Cart	ME-6950 or ME-6951 or ME-9430
Motion Sensor	PS-2103 or CI-6742
Base and Support Rod	ME-9355
Dynamics Track	ME-6958

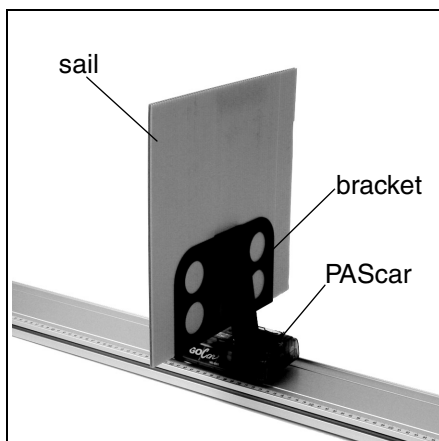
## Introduction

The Car Sail (ME-9595) allows students to observe the effects of air resistance on the motion of an object. In addition, the sail(s) can be fastened to a Dynamics Cart, PAScar, or GOcar and used along with a Dynamics Track to discover the concept of terminal velocity. A sturdy mounting bracket is included to which any of the three sails may be easily attached to a PASCO car. For further investigations, students can create their own sails from standard cardboard and investigate the relationship between surface area and terminal velocity.

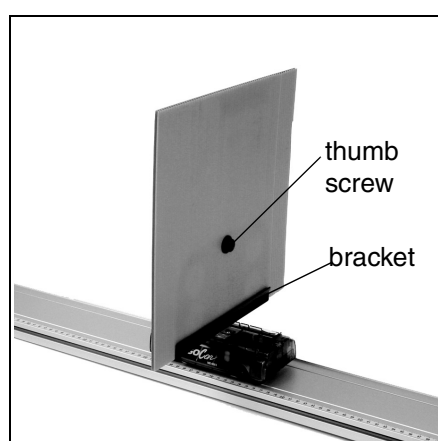
## Equipment Setup

### Attaching the Sail to a Cart

1. Use the small thumbscrew (6x 0.25) to mount the base of the bracket to the cart.
2. Insert the sail into the bracket.
3. Use the large thumbscrew (10-32x 1/2) and washer to attach the sail to the bracket. (The screw inserts through a hole in the bracket and a cut hole in the sail.)



**Figure 1a: Sail in Bracket (front view)**



**Figure 1b: Sail in Bracket (back view)**

## Suggested Experiments

### Experiment 1: Investigating Air Resistance

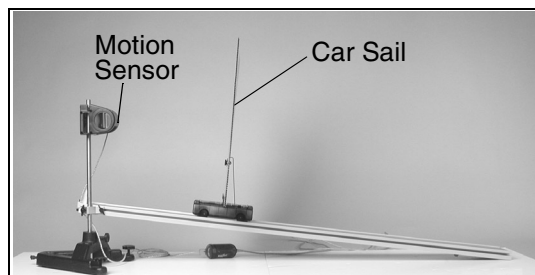
Equipment Required:	
Car Sail (ME-9595)	DataStudio Software, version 1.5 or later (various, see PASCO catalog)
Motion Sensor (PS-2103 or CI-6742)	<i>ScienceWorkshop</i> or PASPORT interface (various, see PASCO catalog))
PAScar, GOcar, or Dynamics Cart (ME-6950 or ME-6951 or ME-9430)	Dynamics Track (ME-9453)
Base and Support Rod (ME-9355)	

#### Introduction

In this activity, students will explore the motion of a car as it rolls down an incline with various sails attached to it.

#### Procedure

1. Mount a steel rod to a base support.
2. Clamp the Dynamics Track to the rod, and incline the Dynamics Track at a small angle (5 degrees or less).
3. Clamp a Motion Sensor to the upper end of the rod.
4. Connect the Motion Sensor to an interface (PASPORT or *ScienceWorkshop*) connected to your computer.
5. Set the range switch on the Motion Sensor to the near (cart) setting.



**Figure 2: Car (with sail) released from upper end of Dynamics Track**

6. In DataStudio, create a Velocity-Time graph. (For DataStudio setup instructions, see Appendix A).
7. Place the car on the track (without the bracket or sail).
8. Click the **Start** button in DataStudio; then release the car. Catch the car before it reaches the end of the track; then click the **Stop** button in DataStudio.
9. Insert a sail and repeat Steps 7-8 for each of the sails in the set.

### Analysis

1. Compare the Velocity-Time graphs for each of the four runs.
2. Why does the motion of the car differ for each of the runs?
3. Draw a force diagram for each of the data runs:
  - a) No sail
  - b) Small Sail
  - c) Medium Sail
  - d) Large Sail

## Experiment 2: Surface Area and Terminal Velocity

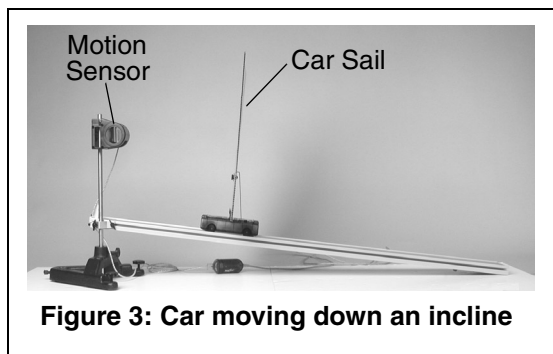
Equipment Required:	
Car Sail (ME-9595)	DataStudio Software, version 1.5 or later (various, see PASCO catalog)
Motion Sensor (PS-2103 or CI-6742)	<i>ScienceWorkshop</i> or PASPORT interface (various, see PASCO catalog)
PAScar, GOcar, or Dynamics Cart (ME-6950 or ME-6951 or ME-9430)	Dynamics Track (ME-9453)
Base and Support Rod (ME-9355)	

### Introduction

After establishing the concept of terminal velocity in Experiment 1, students can use this experiment to investigate the relationship between the surface area of the sail and terminal velocity.

### Procedure

1. Mount a steel rod to a base support.
2. Clamp a Dynamics Track to the rod, and incline the Dynamics Track at a small angle (5 degrees or less).
3. Clamp a Motion Sensor to the upper end of the rod.
4. Connect the Motion Sensor to an interface (PASPORT or *ScienceWorkshop*) connected to your computer.
5. Set the range switch on the Motion Sensor to the near (cart) setting.
6. In DataStudio, create a Velocity-Time graph. (For DataStudio setup instructions, see Appendix A).
7. Place the car on the track with the smallest sail attached.



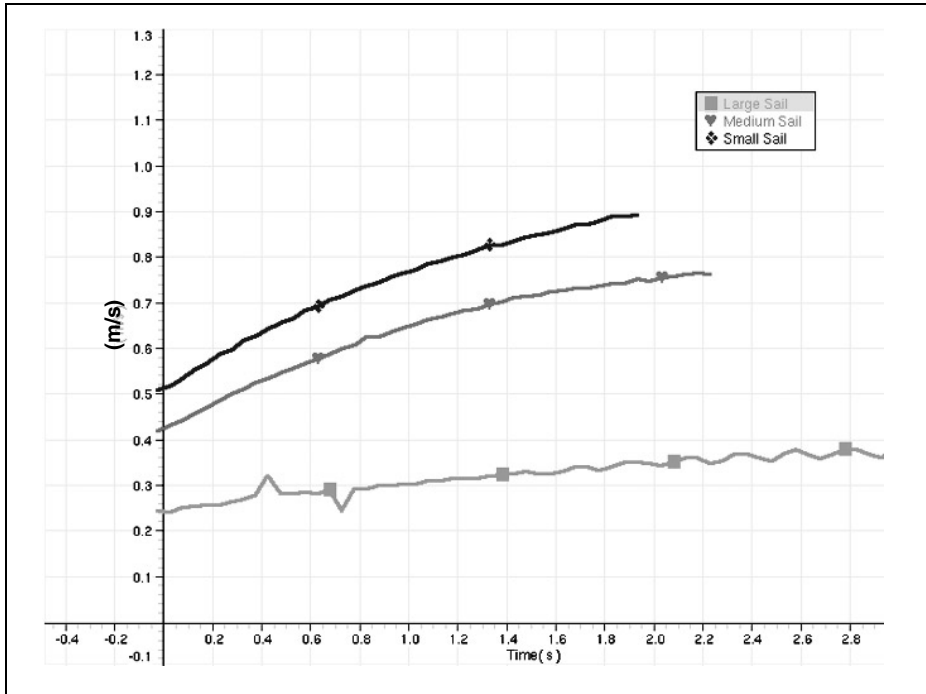


8. Click the **Start** button in DataStudio; then give the car a push down the incline. This is necessary to be certain that the car reaches its terminal velocity.
9. Catch the car before it reaches the end of the track; then click the **Stop** button in DataStudio.
10. Repeat step 7-9 three times.
11. Repeat steps 7-9 for the other two sails.

### **Analysis**

1. For each of the sails, determine the average terminal velocity.
2. Produce a graph of terminal velocity vs. sail surface area. The student may need to create several other sails with different surface areas to establish the relationship between terminal velocity and sail surface area.
3. What does the graph suggest about the relationship between terminal velocity and sail surface area?
4. Explain why this relationship does or does not follow physical intuition.

# Sample Data/Results



## Appendix A: DataStudio Instructions (for *ScienceWorkshop* Sensors)

1. Connect the Motion sensor to digital channels 1 and 2 (or 3 and 4) on the *ScienceWorkshop* interface.
2. Open DataStudio and create an experiment.
3. In the Sensors list, click and drag the Motion Sensor icon to two digital channels on the picture of the interface (the same two numbers to which you have the sensor connected).
4. To create a position vs. time graph, drag the Position icon from the Data list to a Graph display.

OR

To create a velocity vs. time graph, drag the Velocity icon from the Data list to a Graph display.

5. To begin data collection, click the **Start** button.

## DataStudio Instructions (for PASPORT Sensors)

1. Connect a PASPORT interface to a USB-compatible computer.
2. Connect the PASPORT Motion Sensor to a PASPORT interface (USB Link, PowerLink, etc.).
3. When the PASPORTAL window opens, select “Launch DataStudio.” A display will automatically open with time(s) on the x-axis and position (m) on the y-axis.

**Note:** To create a velocity vs. time graph, click the **Setup** button to open the Experiment Setup window. Scroll to the Motion Sensor box and click in the box next to “Velocity.” From the Data list, drag the velocity icon over the y-axis on the graph and release the mouse.

4. To begin collecting data, click the **Start** button.

## Appendix B: Technical Support

For assistance with the ME-9595 Car Sail 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](http://www.pasco.com)  
Email: [techsupp@pasco.com](mailto:techsupp@pasco.com)

## Appendix C: Copyright and Warranty Information

### Copyright Notice

The PASCO scientific 012-08443A *Car Sail Manual* is copyrighted and all rights reserved. However, permission is granted to non-profit educational institutions for reproduction of any part of the 012-08443A *Car Sail Manual*, providing the reproductions are used only for their laboratories and are not sold for profit. Reproduction under any other circumstances, without the written consent of PASCO scientific, is prohibited.

### 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.