



Lesson Title	Fan Carts
Length of Lesson	45 minutes
Created By	Matthew A. Lee, William Funderburk, and Henry Stauffenberg
Subject	Physics
Grade Level	11-12
State Standards	Physics: 1 and 2a
DOK Level	DOK 4
DOK Application	Analyze, Draw Conclusions, and Develop a Logical Argument
National Standards	Physics B
Graduate Research Element	Data analysis, model fitting, estimating error.

Student Learning Goal:

Mississippi Standards:

Physics: 1. Apply inquiry-based and problem-solving processes and skills to scientific investigations.

- a. Use current technologies such as CD-ROM, DVD, Internet, and on-line data search to explore current research related to a specific topic.
- b. Clarify research questions and design laboratory investigations.
- c. Demonstrate the use of scientific inquiry and methods to formulate, conduct, and evaluate laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development).
- d. Organize data to construct graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs) draw conclusions and make inferences.
- e. Evaluate procedures, data and conclusions to critique the scientific validity of research.
- f. Formulate and revise scientific explanations and models using logic and evidence (data analysis).
- g. Collect, analyze, and draw conclusions from data to create a formal presentation using available technology (e.g., computers, calculators, SmartBoard, CBL's, etc.).

Physics: 2a. Use inquiry to investigate and develop an understanding of kinematics and dynamics of physical bodies.

- Vector and scalar quantities
- Vector problems (solved mathematically and graphically)
- Vector techniques and free-body diagrams to determine the net force on a body when several forces are acting on it
- Relations among mass, inertia, and weight



National Standards:

Physics:

Objects change their motion only when a net force is applied. Laws of motion are used to calculate precisely the effects of forces on the motion of objects. The magnitude of the change in motion can be calculated using the relationship $F=ma$, which is independent of the nature of the force. Whenever one object exerts force on another, a force equal in magnitude and opposite in direction is exerted on the first object.

Materials Needed (supplies, hand-outs, resources):

One fan cart (see figure 1) per group, track for the fan cart, force meter, ultrasonic motion detector. (Pasco makes some motion detectors, which we used with our class).

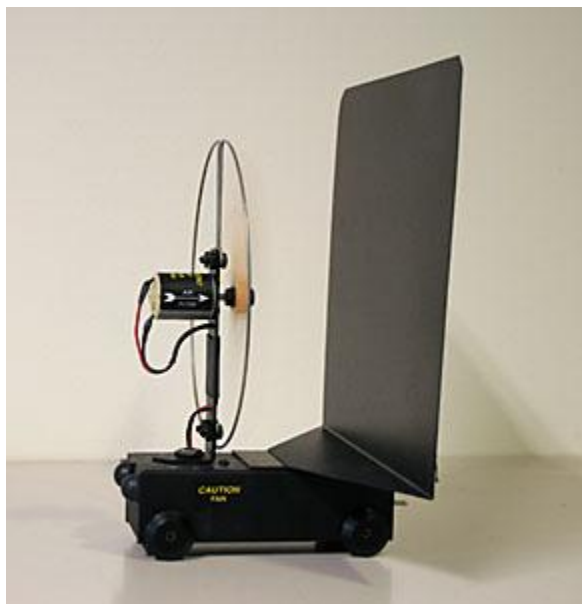


Figure 1. Pasco fan cart with sail.
(We don't use the sail in this lesson.)

Lesson Performance Task/Assessment:

The students will collect data about the fan cart's mass, thrust force, and displacement with respect to time (the ultrasonic motion detector helps with collecting this). The fan on the fan cart is mounted on a swivel that can rotate 360 degrees. The students will study the range of 0 to 90 degrees. The students will compute force using the equation $F = ma$, and compare it to the force they measured for all angles they use. In our experiment, there was about a 5% error. Part of the performance task will be judging the students on how well they pick what fan angles to collect data on. This way they get to design their own experiment to a degree, and they have the opportunity to defend why they chose particular angles.



Lesson Relevance to Performance Task and Students:

The students will learn about force and vectors as well as experiment design.

Anticipatory Set/Capture Interest:

We captured the student's interest by going over a PowerPoint slide show about data collection. (The slide show is included with the lesson plan.) In the slide show, we showed the students examples of how not to collect data and asked them what was wrong with it. At the end of the slide show, there was a slide showing what we wanted the students to do, which we left up for the remainder of the class time.

Guided Practice:

We started the class off with some leading questions about how they should collect data. Then we talked with the class about how the lab equipment works, and what we want them to do. During the lab, we walked around and talked with the students about any questions they had about the lab.

Independent Practice:

The students measured position vs. time for the each angle they selected. We chose to have them do this for 4 different angle settings on the fan cart between 0 and 90 degrees. One of the 4 angles had to be 0 degrees so that the students could compute force from their mass and acceleration. The students would then compare the force valued they measured to the value they computed. The students measured the force by attaching a string between the force meter and fan cart. When the fan cart is not moving and the string is pulled tight, the force meter shows the force of the fan on the cart. The students will use their measurements of the 4 different angles and created graphs of distance vs. time. From these graphs, they could then compute velocity and acceleration for each angle. They can use vector math to explain why changing the angle changes the acceleration they see.

Remediation and/or Enrichment:

You can enrich the lesson by having the students compute trend-lines using Microsoft Outlook. There is a lesson plan describing how to do this, but you can also find information about it on the Internet.

Remediation: individual IEP; partner help throughout the lesson; the teacher can observe the students and intervene during the independent practice.

Check(s) for Understanding:

During the lab, the teacher can walk around and observe the students. If some of the students appear to not understand how the equipment works or what they are expected to do, ask them some leading questions. The students should be able to compute the force and pick angles to measure distance vs. time. If they cannot, it will be apparent because they will not be able to do the lab.



Closure:

We closed by talking to the students about an example of how they should compute their force from the acceleration and mass of the cart.

Possible Alternate Subject Integrations:

Math

Teacher Notes:

We have included the slide show we used to capture the students interest at the beginning of the class.