TEACHERS GUIDE

FAN CART

ITEM # 3568-00

ENERGY - MOTION

This fan cart is ideal for displaying Newton's laws of motion, force, acceleration, and mass in action. This cart is easy to use making it perfect for demonstration of these principles in any classroom. Comes with a removable sail, to display action-reaction and to control motion, as well as different battery clips, for use with one or two AA batteries which helps to show the impact of different net forces on acceleration.

Materials

- 2 AA batteries
- portable fan
- accelerometer or motion sensor
- small plastic plate or bowl
- 7cm x 7cm square of plastic
- pulley
- cord
- hanging masses
- paperclip (or battery clip)

Goals & Objectives

See page 7 for Next Generation Science Standards (NGSS)

INTRODUCTION

Newton's laws of motion can be deceivingly elegant and simple. Providing a multitude of examples of forces and action-reaction pairs can help students to gain a more comprehensive understanding. The opportunity to test these multiple examples can help to break down or prevent common misconceptions.

The Fan Cart provides many opportunities for students of all ages to investigate forces and all three of Newton's laws of motion. The Fan Cart can be used as a full class demo to introduce new concepts or it can be used in small groups for more in depth investigation and experimentation. Using the basic Fan Cart as a starting point, students can be challenged to create their own experimental designs to answer a number of questions about the concepts of force, motion, and acceleration

How It Works

Without a sail (Fig. 1), the movement of the Fan Cart is a classic example of Newton's third law of motion which states that for every action, there is an equal and opposite reaction. As the fan pushes the air in one direction, it creates a force that pushes the fan and attached cart in the opposite direction. As seen in the diagram, the air blows to the left, and the force is created in the opposite direction – to the right. The cart rolls, or accelerates, to the right.

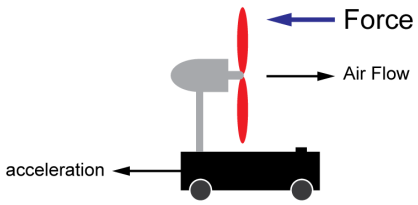
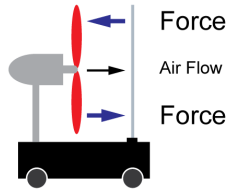


Fig. 1

When the large, flat sail is added to the system (Fig. 2) and the fan is turned on, the force to the right (in the opposite direction of the blowing fan) still exists. At the same time, the air pushes against the sail, creating a force to the left. These two forces are equal and in opposite directions, yielding a net force of zero. As Newton's first law of motion states, when the net forces on an object are zero, the velocity of the object will remain constant. In this case, the velocity is zero. An object at rest will remain at rest, unless acted upon by a net force greater than zero.



Net Force = 0

Fig. 2

ACTIVITIES

For younger students, focus on science practice skills such as predicting, making observations, and explaining at an age appropriate level. More complex physics and mathematical concepts can be addressed using the same activities with middle school students and higher.

1 Before demonstrating Fan Cart, ask students to predict what will happen when the fan is turned on without the sail. Turn on the fan to allow for observations. Have students describe their observations and explain what they think is happening. This activity is a good time to introduce or discuss Newton's third law of motion as they relate to student observations and conclusions.

2 Attach the included sail to the cart and repeat the steps from Activity 1. Introduce or discuss Newton's first and second laws of motion as they relate to student observations and conclusions. For younger students, it may be helpful to also blow the sail using a portable fan (or simply blowing). Have students compare the results between the attached and unattached fans.

Investigate further – The following activities can be set up as investigations that allow students to make observations and explain what is happening. Alternatively, you can challenge students to develop and carry out an experimental design that answers a question posed by the teacher or by the students, themselves.

3 Explore what happens when you replace the included sail with different kinds of sails. Ask students to make predictions and observe what happens. Can they explain the results? Can they draw a diagram that explains their results? Encourage students to invent their own sail ideas or try one or more of the following:

- A concave sail using a small, disposable plastic plate or bowl. Use a hole punch so that it can be attached easily.
- Try a concave sail, as before, but turn it around so that the other side is blown by the fan. Are the results the same or different?
- A smaller sail made out of plastic. A 7cm by 7cm square cut out of a plastic disposable plate could work.
- Use the original sail, but

***Note**

It is always wise to DO an experiment ahead of time to be able to best present it to the class.

ACTIVITIES

Activities continued

devise a way to tilt it to the side or forward or backward. Try various angles.

4 Determine the force of thrust on the fan cart by creating an equal force in the opposite direction that can be easily measured. Challenge the students to develop their own experimental design or set up a pulley system in which the Fan Cart is attached to a hook by a cord run over a pulley. Add masses at increments until the Fan Cart remains stationary when the fan is turned on (when the force of the masses pulling down balance the force of the thrust of the fan). Convert the mass into newtons to determine the force of the thrust (see Fig. 3 below).

Compare the effects of changing the energy in the system by repeating the investigation using only one AA battery. In place of the second battery, use a paperclip or other metal clip (such as a battery clip) to complete the circuit.

5 Investigate the relationship between force and acceleration. Using an accelerometer, motion sensor, or tape timer to measure acceleration, try one or more of the following investigations:

a Use the cart without a sail. Add masses to the cart and take acceleration measurements for varying mass measurements. Don't forget to include the mass of the cart, itself! Create a graph with the data. Mass should be on the x-axis, acceleration on the y-axis. Describe the relationship between mass and acceleration.

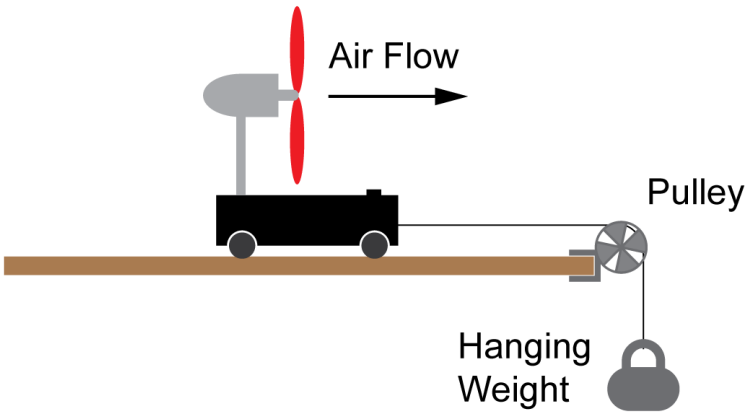


Fig. 3

ACTIVITIES

Activities continued

Do your results support Newton's second law of motion? Why or why not?

b Measure acceleration for the Fan Cart without a sail. Use the mass of the cart and the acceleration to determine the net force acting on the cart. Is this force the same as the force determined in Activity 4? Why or why not?

c Measure acceleration for the various types of sails used in Activity 3 and compare to the acceleration of the Fan Cart without a sail. Use the equation F=ma (Force=mass x acceleration) from Newton's second law of motion to compare the net forces. Discuss what happens to the "lost" force in each of the different situations.

d Use a paperclip to replace one of the batteries. Compare acceleration rates using one and two batteries. Using the equation F=ma from Newton's second law of motion, determine the net force created when using one and two batteries. Discuss the relationship between battery voltage and net force in the system.

DISCUSSION

Additional Discussion and Real Life Applications

1 What other systems or machines use thrust in order to move/ accelerate? How do these systems or machines work?

2 How does friction act as a force and impact the Fan Cart? How does the consideration of friction as a force affect your conclusions in each of your investigations with the Fan Cart? Does it play a role in every investigation or only specific investigations?

3 Newton's laws of motion, developed in the late 1600's can seem very intuitive. Why do you think it took people so long to actually express such seemingly simple concepts?

4 Some people have argued that a sailboat cannot be powered by using an onboard fan to blow the sail. Based on your investigations, do you agree? Why or why not?

GLOSSARY

Vocabulary:

- acceleration
- action-reaction pair
- force
- friction
- mass
- newton
- Newton's Laws of Motion
- thrust

Next Generation Science Standards

Students who demonstrate understanding can:

K-PS2-1. Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.

K-PS2-2. Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.

3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.

3-PS2-2. Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.

Standards Key

K = Kindergarten
3 = 3rd Grade
(numbered by grade)
MS = Middle School
HS = High School
PS = Physical Science

MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

HS-PS2-1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.


American
SCIENTIFIC