TEACHERS GUIDE

ATMOSPHERIC MAT
ITEM # AR-510

MECHANICS - DEMONSTRATION DEVICES

This durable, thick rubber mat has a simple design that demonstrates a powerful concept - Atmospheric Pressure. Pick up an ordinary flat lab stool or make a challenge to lift the mat off a table, which is nearly impossible! Show how suction cups stay stuck because of the pushing force of air, not from a pulling “suction” force. Explore additional concepts such as surface area, force, vacuums, and pressure. Measures 10.5” x 10.5”.

Materials

- atmospheric mat
- trash bags
- straws
- paper cups
- lab stool
- vacuum cleaner
- bell jar with vacuum pump
- index card
- balloon
- small jar

Goals & Objectives

see page 8 for National Next Generation Science Standards

Introduction

The pressure exerted from air is actually very strong. We are accustomed to feeling it push on us from all directions at all times. It's typically when we change altitude or swim deep below water that we notice changes in the pressure around us. The atmospheric mat is a favorite demonstration to show the powerful force exerted by air pressure.
Students are amazed that they cannot lift the mat straight up, but it removes easily when lifted by the corner.

They mistakenly refer to as suction force, which does not exist. All forces are pushes or pulls. If air cannot push equally in all directions on an object it (the air) will push the object towards the low pressure zone. This is how "suction" cups work. A low pressure zone is created under the suction cup when an object pulls on it, and higher the higher air pressure in front of it pushes the suction cup inwards. There must be more air pressure pushing in than there is gravitational force pulling down or the suction cup and object will fall.

The atmospheric mat does not look like a suction cup and demonstrates air pressure without the preconceived notion of suction creating a discrepant event to open discussion about air pressure with your students.

Follow up with additional activities that they have experienced as "suction" to reinforce the new idea about forces only being pushes or pulls.

How it works

Air pressure is a force applied per unit of area. The atmospheric pressure mat is approximately 10.5 x 10.5 inches and it does not let air under it when pulled straight up because of a tight seal between the rubber and surface.

There is approximately 1620 lbs of pressure pushing it down from the air mass above it and as long as no additional air can get under the mat it can theoretically lift that much pressure. In reality, it's much less because of the imperfect seal between the mat and object and the small quantity of air under the hook.

As you pull up on the hook, the small quantity of air under it has a greater volume (gasses expand) and that creates a low pressure compared to the high pressure above it. This allows the mat and object it is lifting (which still has air pushing it up under it) accelerate up together when you lift the mat by the hook.

If you lift the mat by the corner air can get under it and push up as well as the air pushing down and therefore lifts easily.

ASSESSMENT

1
- Participation
- Discussion Questions
- Vocabulary

2 **Glossary/Vocabulary:**
air pressure
psi
balanced forces
pushes
pulls
lift

ACTIVITIES

1a Ask a student to left the mat using the hook. Ask your class to explain why it cannot be lifted easily. (Usually they will refer to suction)

b Lift the mat from the corner to check for this suction. Nothing? Ask them to try explaining again. Why can it be lifted easily from the corner but not straight up?

c Place the mat on a lab stool and lift the lab stool.

Older students can calculate the theoretical maximum weight that the mat can lift.
Why is the actual weight less?

Ask students what is in the space under the hook when you are pulling it up. (small volume of air expanding)
What does this do to pressure under the hook? How does this affect the maximum weight the mat can lift?

d Since there is no suction force how do suction cups work? Physic students should draw a force diagram to represent their idea.

2a How does a straw work?
Many students think they suck the liquid up to their mouths. But, hopefully they are starting to challenge their notion of a suction force.
Use small paper cups with fresh water in them and give each student two straws. One straw should be in the water and the other outside the cup in the air.
Try to "suck" liquid up the straw now. (They will find that this will not work)
Put both straws in the liquid and try. What is different?
Straws work becouse you pull the air out of the straw with your lungs and air pressure pushing down on the surface of the water pushed the water up into the low pressure zone inside the straw. When you have a straw outside of the liquid at the same time you cannot create the low pressure zone in the straw inside the liquid.

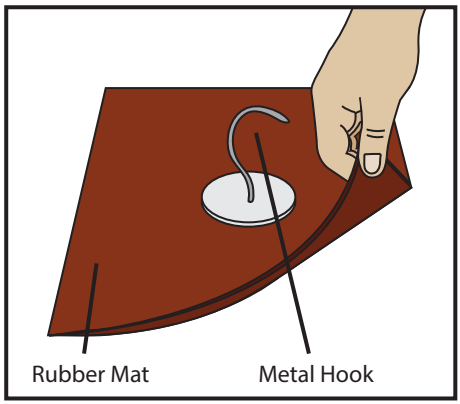
b What is the maximum height air pressure can push a liquid upwards? (about 30 ft due to the weight of the water – gravity pulling it down while air pressure pushes it up)

3 Ask a student volunteer to sit in a large trashbag just over the top of their shoulders and hold the bag tightly sealed after you have inserted the vacuum hose into the top of the bag.

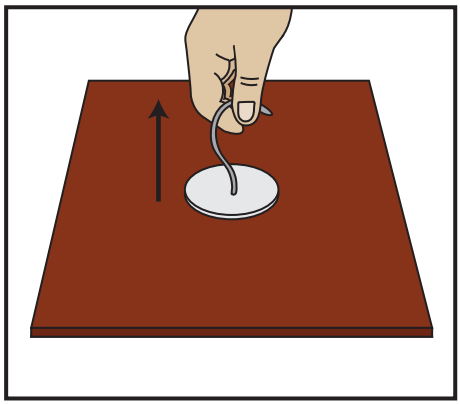
***Note**
It is always best to DO an experiment ahead of time to be able to best present it to the class.

ACTIVITIES

1 See Activity 1 a and b



Lifting the mat by its edge is easy.



Lifting the mat up vertically by the hook is hard.

4 The vacuum pulls the air out of the bag and the air outside of it pushes the bag into the low pressure zone.

a How many books can you lift with air?
Give each student 1 straw and 1 large plastic bag. Show the students how to put a straw in the bag opening and twist the bag opening around the straw to seal it. Hold the twisted bag opening tightly over the straw.
Have students put a book on their large plastic bag and blow in the bag. What happens?
- Book goes up

b Predict how many books you can lift and experiment.
- You are creating a high air pressure zone inside the bag and it pushed the books up because the air pressure around them is lower.

5 Can air lift a person?

a Place the large garbage bag with straws taped tightly into the bag in the four corners on a lab table.
A student can lie down on the bag. Have students tape their straws into the bag straws and blow together to lift the person.
Teach the students to blow 3 times and then put their tongue over the hole and rest for a second.

b Ask your students if air has mass. (It does.)
Provide evidence of this by massing an empty balloon and then fill it and mass again.
Put the filled balloon in a bell jar attached to a vacuum pump. The vacuum pump removes the air outside of the balloon and the air pressure inside pushes the balloon out equally in all directions. (It expands as it does this)

ACTIVITIES

Student Activities *continued*

b Ask your students if the air mass inside the balloon is greater now. (No) What is greater? (volume) How does this affect the density of the air inside the balloon compared to the air density outside of it? Older students can draw particle diagrams of this in chemistry and force diagrams in physics.

6 Fill a small jar or cup with water and place an index card on top. While holding the index card turn the jar upside down.
Remove your hand.

The index card holds the water up in the cup. Air pressure is pushing up more than the combination of air pressure in the cup is pushing down and gravity is pulling down on the water.

1 See Activity 1c:
Lift a bar stool, side table, or other object with a flat top with the Atmospheric Mat.

Discussion

Additional Discussion and Real Life Applications

1. How do airbags use air pressure for safety during collisions?
2. What other ordinary objects do we use that utilizes air pressure?
3. How does air pressure work on an airplane?
   How can they fly? Don't let them escape with just responding with lift. How does air pressure produce lift?
4. How does air pressure impact our weather?

   Is there more or less air pressure in Colorado as compared to Ohio?
5. When air pressure is reduced on one side of an object are the forces acting on the object still balanced? If not, how does the objects motion change?
6. Does fast moving air produce the same pressure?

National 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.

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.

MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures.

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.

S-PS2-3. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.

Standards Key

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