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.

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.

3-PS2-3. Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.

3-PS2-4. Define a simple design problem that can be solved by applying scientific ideas about magnets.

MS-PS2-1. Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.

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.

MS-PS2-3. Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.

MS-PS2-4. Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.

MS-PS2-5. Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.

Standards Key

K = Kindergarten
3 = 3rd Grade
MS = Middle School
HS = High School
PS = Physical Science
LS = Life Science
ES = Earth Science

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.

HS-PS2-2. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.

HS-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.

TEACHERS GUIDE

GRADE LEVEL K-COLLEGE

AIR PUCK
ITEM # 3569-00

ENERGY - MOTION

Demonstrate Newton's Laws, energy, and momentum with the amazing new Air Puck! It's perfectly balanced and glides on a cushion of air for nearly frictionless motion across any smooth surface. Sturdy bumpers will survive collisions with walls, shoes, or other Air Pucks.

Materials

- Air Puck
- Tape Measure
- Masking Tape
- Stop Watch
- 4 AA Batteries
- Cardboard Square, 2x2 inches
- Different Floor Surfaces

- Spring scale
- Velcro

- String
- Broom
- Index card
- Fan
- Small hook
- a few balloons
- a few magnets

- **Optional:** second soccer air puck, a rubber band.

Goals & Objectives

Students will:

- observe airflow and a lack of air flow.
- describe lift.
- understand friction.
- understand air pressure differences.
- understand forces.

Assessment

Vocabulary Sheet

1 **Scientific Terms for Students to Understand:**
Airflow
Air Cushion
Friction
Lift

2 **Answers:**
Airflow – movement of air due to differences in air pressure.
Air Cushion – air trapped by the skirt under air puck.
Lift – is a force lifting air puck up.
Friction - resistance to movement that occurs when two objects are in contact.

Enrichment

1 **Collisions** – conservation of momentum.
Use the second air puck to demonstrate collisions between two objects. Use the Velcro and rubber band to accelerate the air pucks towards each other. What about one collided with the other while they travel in the same direction? Perpendicular directions?

2 **Airbags** – impulse.
Use the balloons as airbags and attach one to each air puck. Small water balloon size works best. Collide the air pucks into each other now. Does it affect the motion? How?

Discussion

1 Use the Internet to look up images and information for Hovercrafts. Compare the air puck's operating components to the Hovercrafts' operating components.

Student research and explain advantages of using Hovercrafts.
a. Conserving fossil fuels
b. Saving the environment from pollution

Expand on how are Hovercraft vehicles used commercially?
a. Transportation
b. Rescue Operations where other vehicles cannot travel.

2 Students can discuss the application of forces to explain athletics, airbag use in automobiles, how planes stay in the air, why boats float instead of sink.

3 Encourage discussion of force pairs. Why do things break? Are the action-reaction force pairs still equal in size, but opposite in direction?

4 Encourage students to design experiments, and suggest measurements to take in order to make conclusions regarding strength of pushes and pulls and changes in motion.

ACTIVITIES

Student Activities *continued*

non-hovering air puck.

6 Force Pairs
Newton's third law states for every action there is an equal and opposite reaction. This involves two objects and they each exert a force on each other. The air puck exerts a force on the floor and the floor exerts a force on the air puck. They are identical in magnitude, but opposite in direction. When you push the air puck with the broom the broom pushes back. Can you see the broom bristles bend? That is the push back. The change in motion produced isn't the same, but the forces they exert on each other are.

7 Centripetal Force and Inertia
Use the Velcro to attach a string to the air puck. Pull the air puck around you in a circle. A constant unbalanced force pulling it to the center of the circle is needed in order for circular motion to occur. If you release the string you can observe the objects inertia and it will travel in a straight line perpendicular to the circle.

8 Magnetic Forces
Use the Velcro to attach a magnet to the air puck. You can use the other magnet to demonstrate invisible forces acting on each other – attractive or repulsive. Using more/larger magnets should result in greater repulsions and attractions.

9 Static electrical forces
Attach an inflated balloon to the air puck. Charge a second balloon with fur (or your hair) and bring it close to the first balloon. This demonstrates another invisible force – static electricity. Did it attract or repel? Why? Can you reverse it?

10 Gravity
Use the Velcro to attach the hook to the top of the air puck (do not block the air vent). You can use the spring scale to demonstrate gravity does not change when it is hovering. It does not matter if it is the floor pushing on it or the air. What would change the force of gravity between the air puck and the earth?

11 Sail boat air puck
Attach the index card to the air puck to make a sail. You can blow or use a fan to make it sail.

**for older students standardized tests will expect them to identify the forces using their proper names, gravity, normal, lift, friction, etc.*

For Enrichment Activities, see page 7.

Assessment
Participation, Vocabulary Sheet, Diagrams

How does it work?

Physics – Airflow Creating Lift

- The air puck lifts off the ground and moves with only air underneath it.
- Why does airflow cause an object to rise upward?
- Is the air pressure greater above or below the air puck?
- How can air, we breathe, become sources of energy?

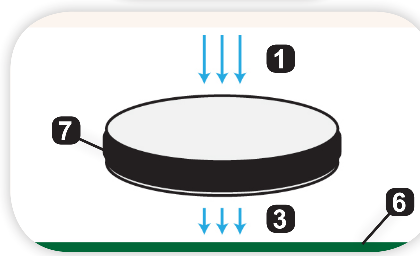
Students will use the air puck to visualize the power of airflow as well as understand air pressure, lift, and friction. The air puck's internal fan takes air from the top and pushed it downward. As air flows downward and out the bottom of the device, it builds up air pressure underneath which is contained by the skirt (physical ring under the air puck). The air puck lifts off the surface and glides.

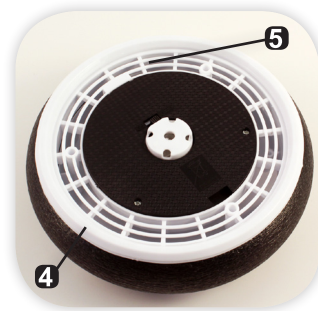
Forces – Pushes and Pulls in Pairs!
Pick any object (yourself, the dog, an airplane, a soccer ball) and it never has only one force pushing or pulling on it – ever! Moving or not moving – there is always a force pushing or pulling on you and you push or pull right back. Make no mistake - you resist that push or pull and whatever is pushing or pulling on you, resists you. If two objects are touching each other then they are pushing or pulling on each other exactly where they are touching. We name these pushes and pulls after whatever is pushing and pulling. Sometimes the pushes and pulls are between two objects not touching each other – invisible forces! Invisible forces include gravity, electrical, and magnetic. Interestingly, gravity is always a pull, but electrical and magnetic forces can be a push or pull (attraction or repulsion).

The soccer air puck will let you explore balanced forces on a moving and nonmoving object, unbalanced forces, and force pairs. Most exciting of all, you can significantly reduce the force of friction to observe Newton's First Law of motion: an objects resistance to pushes and pulls (inertia); Newton's second law: the size of the force applied divided by the mass of the object equals the acceleration; and Newton's third law: for every push or pull there is an equal push or pull in the opposite direction.

Setup & Components

1. Outside Air
2. Fan (inside air puck)
3. Air Underneath
4. Skirt (white perimeter solid ring)
5. Trapped Air Cushion within Skirt (Plenum Chamber)
6. Hard Surface (floor)
7. Air Puck





ACTIVITIES

1 Use the Air Puck
Insert four AA batteries according to the directions. Move the switch on the bottom to the 'on' position powering the internal fan. Place the air puck on a smooth floor and notice the air puck's movement. Have students feel the air around the perimeter of the air puck. Discuss how the fan is creating a greater air pressure under the air puck creating lift. We often refer to air pressure differences as 'wind' outside.

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

2 Identify Parts of the Air Puck
Students look at the air puck and identify the location of air intake on top and bottom. Look for the hard ridge around the perimeter of the bottom, called a skirt or curtain. The skirt temporarily traps the air creating an air cushion, called a plenum chamber. The air cushion helps to contain the air and a greater air pressure under the air puck resulting in lift.

3 Air Flow Experiment
Use masking tape to tape the 2-inch-by-2-inch cardboard over the top air intake. Turn the air puck on for a short time. Notice the movement or lack of movement. Why is there no lift?

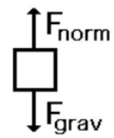
4 Friction Experiment
Use the air puck on several different floor surfaces. Notice the speed differences.

Advanced: Place the air puck on 'Surface Number 1'. Mark the starting point with a piece of masking tape. Turn the air puck on and at 15 seconds (using the stopwatch) mark the distance the air puck traveled. Measure the distance in inches and write it down (for 'Surface Number 1).

Repeat above for different surfaces. Make a chart of 'Surface Number' and 'Distance'. Graph the results with distance on the y-axis (vertical axis) and Surface Number on the x-axis (horizontal axis). Be sure to keep the time constant. Discuss the concept of changing variables and constant variables. Discuss why the air puck traveled different distances on different floor surfaces.

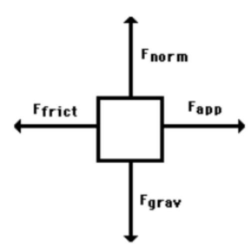
5 Draw free body diagrams for the following and ask students to identify the forces acting on the air puck in each.

a Balanced Forces
Balanced forces on the stationary air puck – not hovering. Normal Force can also be labeled the force of the floor or F_{floor}. It's also useful to label the force of gravity as the F_{earth} to emphasize that gravity the force of attraction between two objects. Since the motion of the puck is not changing in speed or direction then the forces are balanced. We know the force of gravity is there; since the puck is not accelerating through the floor then the floor must be pushing back. These two forces are equal in size and acting on the same object, but in opposite directions. *



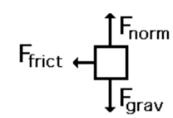
Balanced forces on the stationary air puck – hovering. The motion of the air puck is still not changing, but the force of the floor is no longer there – it is now lift or F_{air} to keep the pattern of naming the force after what is causing it. Still equal in size but opposite directions.

Balanced forces on the moving air puck – not hovering. This requires some practice. Use the broom to apply a continuous force (the broom stays in contact with the puck). This is the first time students will need to identify horizontal forces in addition to the vertical ones already identified. If the motion of the air puck is not changing then all forces are still balanced. How can it be moving and not changing? Students should identify the force of friction and the force of the broom as equal in size but opposite in direction.



Balanced forces on the moving air puck – hovering. Constant applied force from the broom while moving. What happened to the size of the horizontal forces? (they BOTH got smaller – reduced friction means less applied force is needed) Did the vertical forces change? (no)

b Unbalanced Forces
Unbalanced forces on the air puck – not hovering. Sharp push with the broom with loss of contact. The free body diagram should be for after the broom is no longer touching the air puck. This is the first time to draw unbalanced forces and observe how the motion changes. The puck slows down without the push to balance the friction.



Unbalanced forces on the air puck – hovering. Two different diagrams. One in which you apply a continuous force with the broom which is greater than friction and the air puck undergoes continuous acceleration (gets faster and faster) or you can apply a sharp push with the broom and then the friction slows it down. The force of friction is greatly reduced compared to the force arrow in the