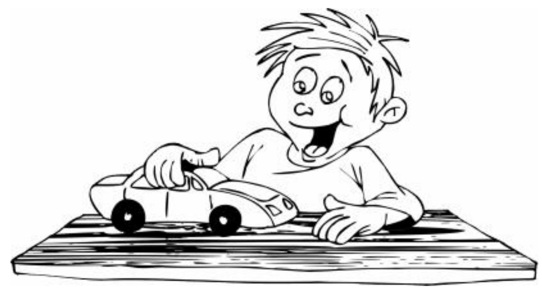
Unit 2 Cycle 1

Beginnings: What are forces?

Purpose



When studying the world, it is useful to think about how objects affect each other. When this happens we say that there is an ***interaction*** between the objects involved. (Another way of saying this is that the objects are ***interacting*** with each other.)
For example, in Unit 1 when you investigated changes in motion, each time you pushed the ball, there was an interaction between your hand and the ball.

One way scientists describe interactions between objects is in terms of what they call ***forces***. The pushes you used are examples of forces. In this Unit we will investigate the connection between a force and the effect it has on the motion of an object. However, to start we must think about what we mean by "force". The big question we will address in this *Beginnings* activity is:

> ***What is a force, and what are some examples of forces?***

What do we think?

You will work with a partner for this activity. Each pair will need:

- Toy car

Place the toy car on the table. One of you should give it a quick push so that it starts moving. While the car is in motion the other partner should stop it suddenly.

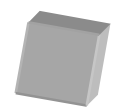
Do you think a force was acting on the car while it was starting to move? Explain your answer.

Describe another way you could start the car moving across the table.

Do you think a force would be acting on the car in your suggested method? Explain your answer.

Your teacher will lead a class discussion about everyone's answers to these questions, and the explanations of their thinking.

Activity: Are pulls forces too?



You will work with a partner for this activity. Each pair will need:

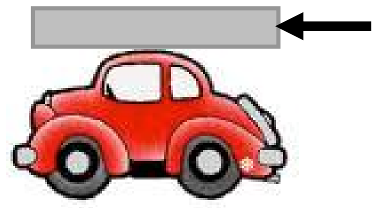
- Toy car
- Small mounting square (or double sided tape)
- Larger square of soft foam

STEP 1: Hold the foam square in one hand and push on its edges with your other hand.

Describe what happens to the edges of the foam square when you push on them. Do they stay the same or do they change in some way? Describe what happens.

Because we know that your pushes are examples of forces being applied, we can use the foam square as a "force detector." ***We will take any change in shape of the foam square as an indication that a force is acting on it.***

STEP 2: Use the mounting square to attach the foam square to the top of the car. From now on you can consider the foam as being part of the car. Use your finger to start the car moving, by giving the back edge of the foam a quick push.



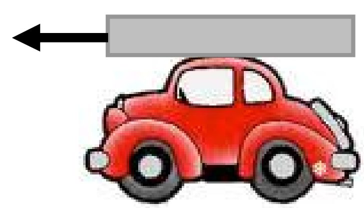
After the car has moved short distance, give the front edge of the foam a "backwards" tap to make it stop. (Do NOT make it go backward.)

Did a force act on the car while you were interacting with it to make it start moving? What about while you were stopping it? How do you know?

STEP 3: Apart from pushing on it, another way to interact with the car would be to pull on it in some way.

You know that pushes are examples of forces, but do you think pulls are also examples of forces, or not? Why do you think so?

Return the car to its starting point and start it moving again, this time using a quick firm **pull** on the front edge of the foam.



After the car has moved a short distance, give the back edge of the foam a 'backwards' pull to make it stop. (Do NOT make it go backward.)

Did a force act on the car this time while you were interacting with it to make it start moving? What about while you were stopping it? How do you know?

What do your observations of the behavior of the foam during your pushes and pulls suggest? Is a pull another example of a force, or not? Explain your thinking.

Your teacher will lead a class discussion about everyone's observations and what they tell us about whether a pull is a force or not.

Making Sense

Your teacher will lead a class discussion about forces. Write answers to the following questions after each one is discussed by the class.

1. Describe what is meant by a force.

2. In this activity it was your hand that applied the forces to the toy car. Describe two other ways you could arrange for a force to be applied to the car. (Make sure one is a push and the other a pull.)

3. What happened to the motion of the toy car each time a force was applied to it? Did its motion change or did it stay the same?

4. If you wanted to change the motion of an object do you think you would have to apply a force to it, or could you change it without a force? Explain your thinking.

Unit 2 Cycle 1

Exploration #1: When does a force stop?

Purpose

You know that when you push or pull on an object you apply a force to it. But when does that force stop acting on the object?

For example, when you hit a tennis ball, the racket exerts a force on the ball. But when does the force of the hit stop pushing on the ball?

The big question we will address in this *Exploration* activity is:

When does a force stop pushing on an object?

What do we think?

Imagine a soccer player taking a shot on goal. She runs up and kicks the ball which flies toward the goal, where the goalkeeper catches it.

Which of the choices below is closest to when you think the force of the kick stopped acting on the ball?

a) Before the ball lost contact with the foot
b) At the moment the ball lost contact with the foot.
c) After the ball lost contact with the foot, but before it got to the goalkeeper.
d) When the goalkeeper stopped the ball moving.

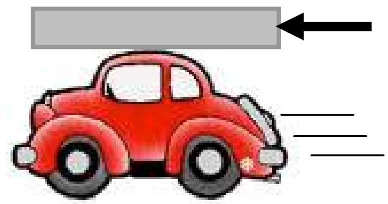
Explain your choice.

Your teacher will lead a class discussion about everyone's answers to this question, and the explanations.

Activity: When is the force there?

You will work with a partner for this activity. Each pair will need:

- Toy car with foam square still attached



STEP 1: Use your finger to start the car moving, by giving the back edge of the foam a quick push. This time, as the car is moving, give the back edge of the foam some more quick 'forward' pushes to increase the car's speed. Watch the edge of the foam carefully before, during, and in between your pushes.

Was a force pushing the car forward while your finger was touching the foam, **<u>during</u>** your pushes? How do you know?

Was a force pushing the car forward while your finger was not touching the foam, **<u>in between</u>** your pushes? How do you know?

STEP 2: Return the car to its starting point and start it moving again using a quick firm push. This time, as the car is moving, give the front edge of the foam some very gentle 'backwards' taps to slow and stop the car. (Do NOT make it go backward.)

Again, watch the edge of the foam carefully during, and in between, your taps.

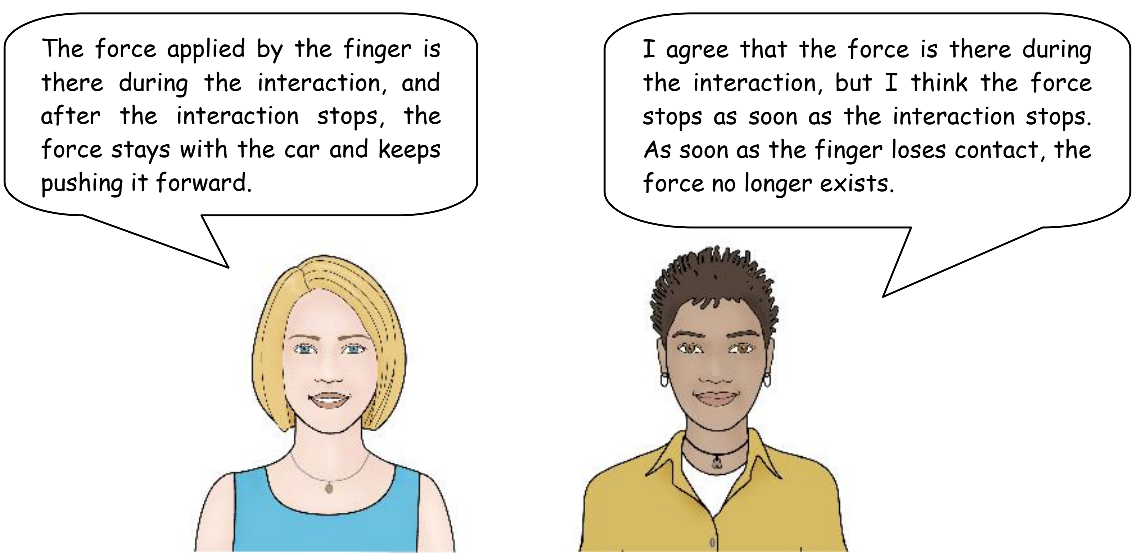
Was a force acting on the car while your finger was touching the foam, **<u>during</u>** your backward taps? How do you know?

Was a force acting on the car while your finger was not touching the foam, **<u>in between</u>** your backward taps? How do you know?

Making Sense

Your teacher will lead a class discussion about everyone's observations and what they tell us about when a force was acting on the car.

1. You know that while your finger was touching the car there was an interaction between your finger and the car. Susie and Katrina were discussing when the force of the finger was being exerted on the car and how it relates to the interaction between them.



Susie Katrina

Do you agree with Susie or Katrina? What evidence have you seen in this activity that supports your thinking?

2. When you hit a tennis ball the racket applies a force to the ball. At what moment do you think the force of the hit stops acting on the ball? Why do you think so?

3. What effect does a force have on the motion of an object? While the force is acting does the object's motion change, or does it stay constant?

4. Do you think a force could be applied to one object, even if it does not interact with something else, or is an interaction with another object needed to create a force?

Unit 2 Cycle 1

Exploration #2: Forces without contact?

Purpose

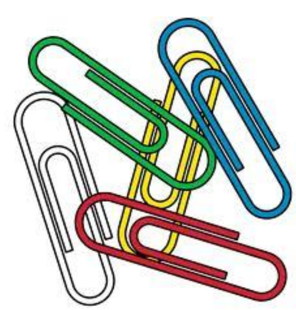
You have observed that in order for you to apply a force to another object, you have to touch it in some way. For example, if you wanted to move a sled across a snowy field, you could do it by pushing it or pulling it with your hands. Even if you used a rope to pull it, then the rope would have to be tied to the sled, and so the rope would be touching it.

But can objects apply forces to each other without touching, or must there always be contact between two objects for a force to exist?

The big question we will address in this *Exploration* activity is:

Can any objects apply forces without touching each other?

What do we think?

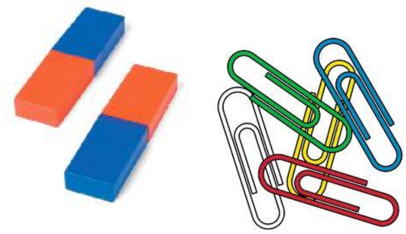


Imagine there were some metal paper clips lying on the table in front of you.

Do you think there is any way you could make them start to move without touching them? If so, how do you think you could do it?

Your teacher will lead a class discussion about everyone's answers to this question.

Activity 1: Playing with magnets



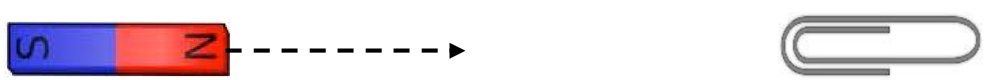
You will work in groups for this activity. Each group will need:

- Two magnets
- Some metal paper clips

STEP 1: ***Each group member should try this.*** Hold one magnet in each hand and slowly bring their ends together until they are almost, but not quite, touching.

Do the two magnets apply forces to each other, even though they are not touching? How can you tell?

STEP 2: Place a paperclip on one side of the table/desk and lay one of the magnets on the other side of the table. Slowly slide the magnet, end first, toward the paperclip.



Describe what happens as the magnet gets close to the paperclip.

Did the magnet apply a force to the paperclip before they touched each other? How can you tell?

Activity 2: Rubbing a balloon

You will work in groups for this activity. Each group will need:

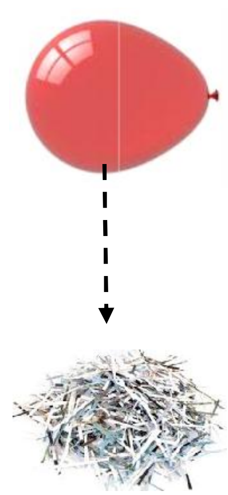
- Rubber balloon
- Some small pieces of paper

STEP 1: Inflate the balloon and tie a knot in the end. (Ask your teacher for help if you can't do this.)

Each group member should try this. Hold the balloon on one side and rub the other side up and down several times on your shirt or sweater. Now quickly bring the rubbed side of the balloon close to, **<u>but not touching</u>**, someone else's hair.

Does the balloon apply a force to the hair? How can you tell?

STEP 2: Place some small pieces of paper on the table. Again, rub one side of the balloon on your shirt or sweater. Now quickly bring the rubbed side of the balloon above the paper on the table. Bring the balloon toward, **<u>but not touching</u>**, the paper until you see something happen.



Describe what happens as the balloon gets close to the paper.

Did the balloon apply a force to the paper before they touched each other? How do you know?

Your teacher will lead a class discussion about everyone's observations and what they tell us about whether objects always need to touch for a force to exist.

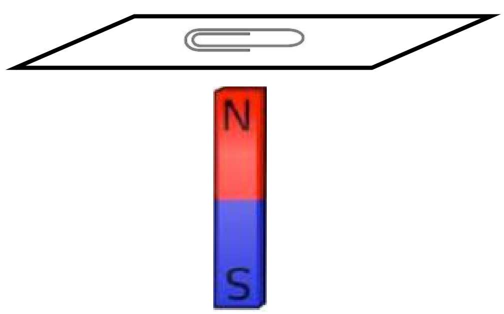
Non-touching Interactions

In order for most objects to interact with each other, and so apply forces to each other, they must be touching. For example, for you to apply a force to a ball, you must touch it, either with part of your body, or with some other object that you are holding. However, in a **few special cases** some objects can interact, and so apply forces, without touching each other.

One common example you are probably familiar with is ***magnetic interactions***. You saw in Activity 1 that magnets can apply forces to other magnets, and some other objects (like steel paperclips), without touching them. In Activity 2 you saw another example, that of ***electric charge interactions***. In this example you gave a balloon an electric charge by rubbing it and then saw that it could apply forces to someone's hair and to some pieces of paper, without touching them.

One interesting thing about non-touching interactions is that sometimes they can make it appear as if an object starts to move on its own. For example, even if a magnet was hidden from view, it could still apply a force to a paperclip and make it move. To anyone who could not see the magnet, it would look like the paperclip is moving on its own.

To see this, have one of your group hold a sheet of paper with a paperclip on it. Then another person should hold the magnet below the paper and use it to move the paperclip around on top of the paper.



To someone looking down from above the paper, it appears as if the paperclip is moving on its own, but really a force is being applied to it by the magnet.

Activity 3: Dropping a ball

You will work in groups for this activity. Each group will need:

- Tennis ball (or similar)

STEP 1: Hold the ball above the ground and release it.

Describe what happens to the ball after you release it.

You know that for the ball to start moving downward a force must be acting on it. What force do you think this is?

You know that for a force to act on one object it must be interacting with another object. A force acted on the paperclips because they were interacting with the magnet, and a force acted on the strips of paper because they were interacting with the charged balloon.

What other object do you think the ball was interacting with, to create the force that pulls it downward?

Making Sense

Write answers to the following questions after each one is discussed.

1. Can some objects apply forces to other objects without touching them? If so, give some examples.

2. When an object falls to the ground, a force must be acting on it. What other object is applying a force to it?

Exploration #3: What happens if a force keeps acting?

Purpose

You know that when you gave a toy car a quick push or pull, your hand lost contact with the car very quickly. This means that the force acting on the car lasted only for a very short time. But what would happen if you kept applying the force so that it continued to act on the car for a much longer time? For example, suppose you were to pull a toy with a string, and keep pulling with the same strength force. What would the motion of the toy be like all the time you were pulling it?

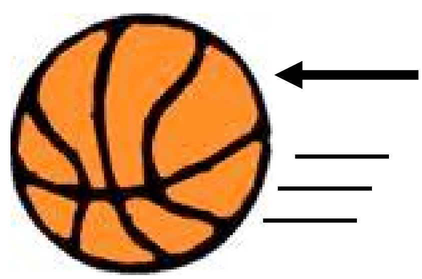
The big question we will address in this *Exploration* activity is:

How does an object move if a force continues to act on it?

What do we think?

In an earlier activity you gave a ball a quick "forward" push as it rolled across the floor.

What effect did the force of your push have on the ball's speed?



Now suppose you arranged for lots of people to each give the ball a quick "forward" push, **one after another**. What effect would the force of each of these pushes have on the speed of the ball?

Your teacher will lead a class discussion about everyone's answers to these questions, and then lead the class in an experiment to check what happens.

Did the ball behave as you expected it to? If not, describe what happened.

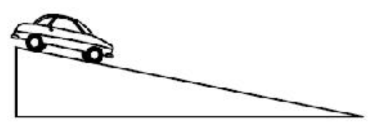
Now suppose you could arrange for each person's push to overlap with each other, with no gaps in between. This would mean that there was a force pushing the ball forward the whole time.

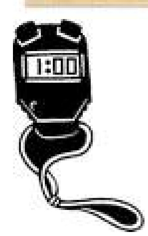
If you were able to do this, how do you think the speed of the ball would behave all the time it was being pushed? Why do you think so?

Your teacher will lead a class discussion about everyone's answers to this question.

Activity 1: Moving down a slope

The whole class will work together on this activity. The class will need:





- Ramp
- Toy car
- Meter ruler
- Stopwatches
- Masking tape

STEP 1: We want to examine what happens to an object when a force acts on it for a long time. In reality, it is very hard for people to apply a constant force on an object for longer than a second or two, so we will have to find another way to do this. We know that Earth pulls with a constant gravitational force on objects, but we also know that it is hard to measure the speed of falling objects because they move so quickly. One way to overcome this problem is to have an object move down a ramp instead. When this happens, the gravitational force is still pulling the object down the ramp, but because the ramp is also supporting the object, it will move down the ramp more slowly than if it fell straight downward. (In effect the ramp is cancelling out some, but not all, of the gravitational force.)

STEP 2: Your teacher will show you a ramp and a toy car. As the car rolls down the ramp the gravitational force of Earth will be pulling on it the whole time.

What do you think will happen to the speed of the car as it rolls down the ramp? Why do you think so?

Suggest a way you could check how the speed of the car behaves as it rolls down the ramp.

Your teacher will lead a class discussion about everyone's ideas and how they could be checked.

Describe how the class has decided to check what happens to the speed of the car as it rolls down the ramp?

STEP 3: The class will now work together to carry out an experiment to measure the speed of the car as it rolls down the ramp.

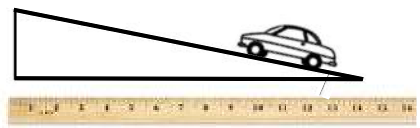
Record the data the class collects in the table below. Your teacher will help you calculate the speed on each stage of the car's trip down the ramp.

Stage	Distance	Time	Speed

What happened to the speed of the car while the gravitational force was pulling it down the slope? Did it increase the whole time, stay constant the whole time, or increase at first and then stay constant the rest of the time?

Activity 2: Moving up a slope

The whole class will work together on this activity. The class will need:



- Ramp
- Toy car
- Meter ruler
- Stopwatches
- Masking tape

STEP 1: In the first activity you saw what happened to the speed of an object when a force keeps acting on it in the same direction as its motion. Now suppose you could arrange for a force to keep acting on an object in the opposite direction to its motion. What would happen to it then?

To check our thinking on this question we need to arrange for a force to keep acting on an object in the opposite direction to its motion. One way to do this is to give the toy car a quick push up the ramp. After the quick push is over the car will still be moving up the ramp, but the gravitational force will keep pulling "backwards" on it in the opposite direction to its motion, down the ramp.

What do you think will happen to the speed of the car as it rolls up the ramp (after being given a quick push at the bottom)? Why do you think so?

Your teacher will lead a class discussion about everyone's ideas and how they could be checked.

STEP 2: The class will now work together to carry out an experiment to measure the speed of the car as it rolls up the ramp.

Record the data the class collects in the table below. Your teacher will help you calculate the speed on each stage of the car's trip up the ramp.

Stage	Distance	Time	Speed

What happened to the speed of the car while the gravitational force was pulling it in the opposite direction to its motion? Did it decrease the whole time, stay constant the whole time, or decrease at first and then stay constant the rest of the time?

Making Sense

Your teacher will lead a class discussion on what happens to objects when a force keeps acting on them. Write answers to the following questions after each one is discussed.

1. When a force keeps acting on an object in the same direction as its motion, what happens to its speed?

2. Suppose one person wanted to check their ideas about forces and tried to keep applying a "forward" force to a ball as it was rolling across the floor. How would that person have to move in order to keep up with the ball and keep pushing on it? Why might this be hard to do?

3. When a force keeps acting on an object in the opposite direction to its motion, what happens to its speed?

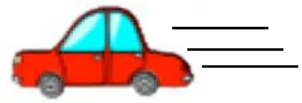
4. When you toss a ball straight up into the air it comes back down. What do you think is happening to its speed on the way up and then on the way back down? How would you explain this behavior in terms of the gravitational force acting on it?

Unit 2 Cycle 1

Exploration #4: Slowing and stopping

Purpose

You have already done several experiments in which you started an object moving with a quick push, but so far we have not studied what happens after such a push.



For example, after you give a toy car a quick push, you know it will get slower and slower, and eventually stop. In this activity we will examine why this happens to most moving objects if the force that started them stops acting.

The big question we will address in this *Exploration* activity is:

Why do most moving objects slow and stop?

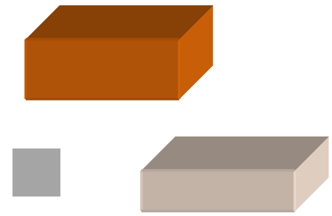
What do we think?

Imagine you were to give a soccer ball a quick kick, so that it rolls across the ground, getting slower and slower, until it comes to a stop.

While the ball is rolling, after your kick, do you think a force is acting on it, or not? Explain your thinking.

Your teacher will lead a class discussion about everyone's answers to this question.

Activity: Why do most objects slow and eventually stop moving?



You will work in groups for this activity. Each group will need:

- Wood block
- Mounting square
- Foam square

STEP 1: Place the wood block on the table in front of you and give it a quick firm push to start it moving. Watch what happens to the block **after your push**.

Describe what happens to the block after your push.

During your push you know that you were applying a force to the block. Do you think a force was acting on the block after your push? Explain your reasoning.

STEP 2: After your push, the block slowed and stopped very quickly. You know that a force acting "backwards" on a moving object can have this effect, but is a force always needed to make this happen, or do some moving objects just naturally slow and stop on their own? In order to investigate this question we will need to find out if a "backward" force acts on the block as it slides across the table.

Use the mounting square to attach the foam square to one face of the wooden block. Place the block on the table with the foam square on the top. Push on the foam to start the block moving, and **keep pushing** so that the block keeps moving across the table.

Was a force pushing "forward" on the block while it was moving across the table? How do you know?

If a force was acting, what other object was the block interacting with to create that force?

Return the block to its starting point and turn it over so that the foam square is now on the bottom (resting on the table). Now push on the block to start it moving, and **keep pushing** so that the block keeps moving across the table. Look carefully at the foam square while the block is moving across the table.

Was a force pushing "backwards" on the block while it was moving across the table? How do you know?

If a force was acting, what other object was the block interacting with to create that force?

Your teacher will lead a class discussion about everyone's observations and what they mean.

Friction

Whenever an object moves across a surface it is touching (or two surfaces rub together), they interact with each other to create a "backwards" force acting on the moving object. We call this type of force a ***frictional force***, or ***friction*** for short. So, as the block moved across the table, the table applied a "backwards" frictional force to the block.

Making Sense

Your teacher will lead a class discussion on friction. Write answers to the following questions after each one is discussed.

1. When you gave the wood block a quick push, it slowed and stopped very quickly. Why did this happen?

2. Place a toy car on the table (or on the floor) and give it a quick push. It should also slow and stop (but move a lot farther while doing so). Why do you think the toy car slowed and stopped?

3. Why do you think the toy car moved a lot farther than the wood block while it was slowing and stopping?

Unit 2 Cycle 1

Application: What if there were no force?

Purpose

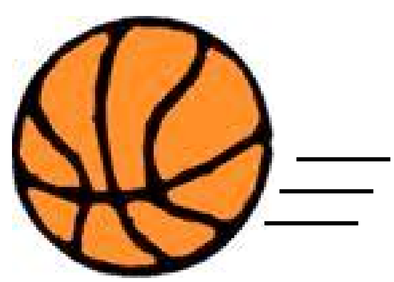
You have now seen that when a force acts on an object, its motion changes in some way; either it gets faster, or it gets slower, or its changes direction. Now we will use these ideas to think about what would happen to an object if **no force** acted on it. In other words, we will investigate what happens to an object's speed and direction during any period of time in which no force acts on it.

For example, suppose you stood on a skateboard and someone gave you a quick push to start you moving. What would your motion be like after their push?

The big question we will address in this *Exploration* activity is:

> ***What happens to an object's speed and direction if no force acts on it?***

What do we think?



When you were experimenting with the ball rolling across the floor, there were periods during which you were not pushing it. What do you think was happening to the ball's speed while you were not exerting a force on it?

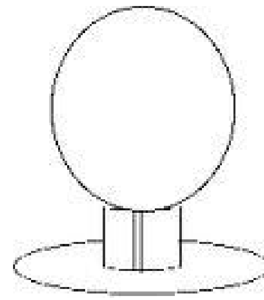
In between your pushes, do you think the speed of the ball was increasing, decreasing, or staying constant? Why do you think so?

Your teacher will lead a class discussion about everyone's answers to this question.

Activity: What if there were no friction?

You will work in groups on this activity. Each group will need:

- CD balloon puck



STEP 1: Place the CD balloon puck on the table (or on the floor) and give it a quick push to start it moving.

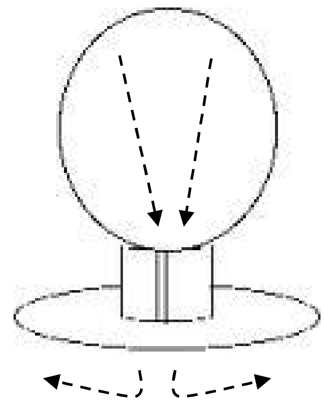
Describe what happens to the puck after your push. Why do you think it behaves like this?

Imagine you could arrange for the puck to move without being affected by a friction force.

If there were no friction, what do you think would happen to the puck after you gave it a quick push? Do you think it would still slow and stop, or would something else happen? Why do you think so?

STEP 2: One way to greatly reduce the effect of friction is to have an object float on a thin cushion of air, like a hovercraft. In this way we can prevent an object from touching the surface as it moves along.

Your CD-balloon puck can be made to behave like a hovercraft. When the balloon is inflated and placed on the puck, air flows down through the hole in the middle and out under the sides of the CD, lifting it off the surface a little. As the puck moves, it rides on this thin cushion of air, rather than actually touching the surface it is on.



Your teacher will instruct you how to use the puck in this way.

STEP 3: Place the puck, with balloon inflated and attached, on the table (or floor). Carefully release the pop-up top so that air can flow to the bottom of the puck. It should now be floating on a very thin cushion of air, allowing it to move across the surface with **<u>little or no friction</u>**.

Give the puck a quick push to start it moving.

What happens to the puck **<u>after your push</u>**? Does it slow and stop like it did in STEP 1, or does it just keep moving?

What does this behavior tell you about its speed **<u>after your push</u>**? Did its speed decrease quickly, or did it stay constant?

After your push, did the puck keep moving in a straight line, or did its direction change?

Your teacher will lead a class discussion about everyone's observations.

STEP 4: Now think about what the puck's behavior **after your push** and what you could do to change its motion in some way.

What could you do to make the puck's speed increase?

What could you do to make the puck's speed decrease?

What could you do to change the puck's direction?

Now use the puck to check your thinking.

Did your ideas about how to change the motion of the puck work?

Why do you think you had to interact with the puck in some way to change its motion?

If you did not interact with the puck in any way do you think it would ever stop moving? If so, why?

Making Sense

Your teacher will lead a class discussion on how objects behave when no forces act on them. Write answers to these questions after each one is discussed.

1. When you start an object moving, and then arrange for no forces to act on it, how will its speed and direction behave? Why is this?

2. Suppose you could attach a very large balloon to the puck and then start it moving down a very long hallway. Do you think it would reach the other end or not? Explain your thinking.

3. Lay your pencil on the table in front of you. As it sits there, its speed stays constant (it stays at zero). Why do you think its speed is not changing?

4. To start your pencil moving you would have to interact with it in some way? Why is this?

5. Suppose a spacecraft is at rest in deep space, far from any stars or planets, so that no frictional or gravitational forces can act on it. Two astronauts want to move the spacecraft to a different place that is far away and discuss how they could do this.

Do you agree with Yuri or Spike? Explain why.

