Unit 1 Cycle 2

Beginnings: Is it moving?

Purpose

So far in this Unit, you have looked at different ways to describe the position of an object that is not moving. However, many objects do not stay in one place but move around; we say that they are ***in motion***.

In the rest of this Cycle we will be thinking about how to describe the motion of an object, and the different ways in which things could move.

To start, we will brainstorm some ideas about how to draw diagrams that show what the motion of an object is like. The big question we are trying to answer in this *Exploration* activity is:

How can we show the motion of an object in a diagram?

What do we think?

Imagine taking a short trip to the store in a car.

While the car is moving, what is happening to its position?

With your partner, try to think of two different ways to draw diagrams that show that the car is moving. In the past people have tried to show what is happening to the car's position. Others have tried to use pictures, symbols, charts, diagrams, graphs, arrows etc.

Sketch your ideas on a presentation board.

Your teacher will lead a class discussion about everyone's ideas on how to show the motion of the car.

Draw two diagrams that are different from your own, but which the class agrees are good ways to show that the car is moving.

What is good about these diagrams?

Activity: How can you tell a motion story?

You will work with a partner for this activity.

STEP 1: Earlier, you considered a short trip to the store in a car. Here are some more details about such a trip.

- When you get in, the car is not moving.
- After a few seconds, the driver steps on the gas and the car starts to move. Its speed then increases for a short while.

- The speed then becomes constant and remains like this for most of the trip.

- As you approach the store, the driver uses the brakes to make the speed of the car decrease and then stop.

STEP 2: Work with your partner to tell the 'story' of the motion of the car during this trip using diagrams.

- Your diagrams should somehow show the different types of motion the car has at different times (increasing speed, constant speed, decreasing speed), and the direction in which it moves.

 Draw your diagrams below and also on a presentation board.

Making Sense

Your teacher will lead a class discussion about people's ideas on how to show the different ways in which the car was moving during different parts of the trip. Write answers to the following questions after each one is discussed by the class.

1. What important pieces of information are needed when describing the motion of an object?

2. Why might it be important to know something about the speed of an object when describing its motion?

3. Why might it be important to know whether an object's speed is changing or staying constant?

4. What are some good ways to show the speed of an object in a diagram?

5. Why might it be important to know what direction an object is moving in?

6. What are some good ways to show the direction of an object in a diagram?

Exploration #1: What causes motion to change?

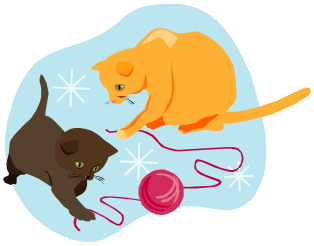
Purpose

As objects move, their motion often changes in some way. A car may be moving fast down the highway and then get stuck in traffic so that it then moves slowly for a while.

In this *Exploration* activity we will examine what it means for the motion of an object to change, and what it is that makes such changes happen.

What are changes in motion and why do they happen?

What do we think?



Suppose your cat spots a ball sitting on a table. She jumps up onto the table and bats the ball, which rolls across the table, falls off, and then rolls across the carpet, coming to a stop. When during this scenario do you think the motion of the ball changed in some way?

To show your group's thinking, draw a picture showing what happens to the ball on a presentation board. Mark where you think the ball's motion changed in some way and label what you think the change was.

What do we mean by a change in motion? What things about the way in which an object is moving could change?

Your teacher will lead a discussion about changes in motion.

Activity #1: How can you change the motion of an object?

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

- Ball (such as basketball or soccer ball)

STEP 1: Imagine there was a ball resting on the floor in front of you, but **not moving.**

What do you think would happen to the ball if you gave it a gentle push?

Now suppose there was a ball rolling across the floor and as it passed by, you gave it a quick, but gentle, push from behind in the **same direction** that it was moving.

Do you think the ball's motion would be any different after your push than it was before? Draw one or more diagrams to show what you think the motion of the ball would be like before and after the push.

Now suppose you gave a slowly rolling ball a quick, but gentle, push from in front, in the **opposite direction** to that in which it was moving.

Do you think the ball's motion would be any different after your push than it was before? Again, draw one or more diagrams to show what you think the motion of the ball would be like before and after the push.

Next, suppose you gave a fast rolling ball a quick, but gentle, push from the side; that is **sideways** to the direction it was moving.

Do you think the ball's motion would be any different after your push than it was before? As before, draw one or more diagrams to show what you think the motion of the ball would be like before and after the push.

Finally, suppose that as the ball was rolling past, you grabbed it firmly with both hands.

What do you think would happen to the moving ball when you grabbed it?

Your teacher will lead a discussion about what effect you think your actions would have on the motion of the ball.

STEP 2: Your teacher will lead the class in testing their ideas. Write the observations that the class agrees on in the last column of the table below.

Motion of ball before	***Action***	***Motion of ball after***
Not moving	*Quick, gentle, push*	
Moving slowly	*Quick, gentle, push in same direction as motion*	
Moving fast	*Quick, gentle, push in opposite direction to motion*	
Moving forward	*Quick gentle push in sideways direction*	
Moving	*Firm grab with both hands*	

Making Sense

Your teacher will lead a class discussion about what effect the pushes (and grab) had on the motion of the ball. Write answers to the following questions after each one is discussed.

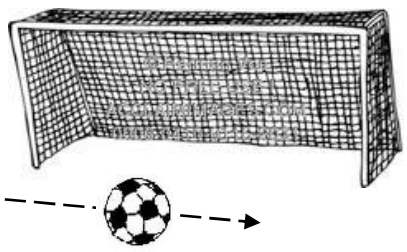
1. In each case, what effect did someone's push (or grab) have on the motion of the ball? Did the motion change in some way or did it stay exactly the same?

2. Do you think the motion of the ball could ever change on its own, or would something else have to touch it to change its motion? Why do you think so?

3. Imagine you are playing in a soccer game.

   a) At one point in the game, one of your teammates kicks the ball softly and it rolls slowly toward the goal. Describe carefully what you could do to increase the speed of the ball, so it reaches the goal before someone on the other team can stop it.

   b) At another point in the game, another player kicks the ball, but it rolls across in front of the goal. Describe carefully what you would to do to change the direction of the ball so it would go into the goal.



Unit 1 Cycle 2

Exploration #2: How fast is it?

Purpose

Peter says that he can run fast, and runs down the sidewalk to show his friends. As he is running, Lynn (who is riding in her mother's car) drives by and overtakes him. Would Lynn agree that Peter is moving fast, or would she see his motion as being slow?

Sometimes using words like *fast* and *slow* is not enough to describe the motion of an object. Instead, it would be better to have a more precise measure of the speed of an object so that moving objects can be compared to each other, even when they are not moving side-by-side. In this *Exploration* we will examine what we mean by the speed of an object, and how we can measure it.

How can we measure the speed of a moving object?

What do we think?

Jasmin and Maria are on opposite teams in a soccer game. At one point in the game, the ball is kicked into an area of the field where there are no players. Jasmin starts to chase after the ball. From a different place on the field, Maria runs after the ball too. Maria reaches the ball first and kicks it to one of her teammates. After the game they discuss what happened and Maria says to Jasmin.

"I got to the ball before you did, so that means I can run faster than you"

Do you agree with what Maria said? Was what happened a fair test to see who could run faster? Explain why, or why not.

Suggest a way in which Jasmin and Maria could check who really is the faster runner? Why would your suggestion be a fair test?

Your teacher will lead a class discussion about how to compare the speeds of two different objects, or the same object at different times.

Activity: Which is faster?

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

- Ball (such as basketball or soccer ball)
- Meter ruler
- Stopwatch
- Masking tape

STEP 1:

- Stick a small piece of tape on the floor.
- Start the ball rolling from the tape and, at the same time, start the stopwatch.
- The group member with the stopwatch should say 'NOW' at the moment the ball has been rolling for 2 seconds, and another group member should note the position of the ball at this moment. (Your teacher will show you how to use the stopwatch.)

Measure how far (in centimeters) the ball rolled in the 2 second period. We will call this RUN 1.

Distance for RUN 1: _____

- Return the ball to the tape and do the same thing again.

- Again a group member should note the position of the ball after it has been rolling for 2 seconds.

 Measure how far (in centimeters) the ball rolled in the 2 second period this time. We will call this RUN 2.

Distance for RUN 2: _____

 Did the ball roll faster during RUN 1 or during RUN 2, or did it have the same speed during both runs? Explain carefully how you know.

STEP 2:

- Stick a second piece of tape on the floor a distance of 200 centimeters from the first one.

- Start the ball rolling from one tape, and now use the stopwatch to measure the time it takes to move between the two tapes.

 Write down how much time it took the ball to roll the 200 centimeter distance between the tapes. We will call this RUN 3.

Time for RUN 3: _____

- Now roll the ball from the second tape back to the first. Again, use the stopwatch to measure the time it takes to move between the two tapes.

 Write down how much time it took the ball to roll the 200 centimeter distance between the tapes this time. We will call this RUN 4.

Time for RUN 4: _____

Did the ball roll faster during RUN 3 or during RUN 4? Explain carefully how you know.

STEP 3: In RUN 1 and RUN 2 you measured how far the ball moved in a time of 2 seconds. In RUN 3 and RUN 4 you measured how much time it took the ball to move a distance of 200 centimeters. But, in which of these four runs did the ball have the greatest speed? To help you think about this, discuss these questions with your group.

If a ball moved a distance of 100 cm in two seconds, what distance would it move in one second at the same speed? How do you know?

If another ball moved a distance of 25 cm in half a second what distance would it move in one second at the same speed? How do you know?

Were the speeds of the two balls in the previous questions the same, or were they different? How do you know?

The speed of an object tells us how far it would move in a certain amount of time at that speed. If a ball is moving such that it would cover a distance of 50 cm in one second, we say its speed is 50 centimeters per second (written as 50 cm/s). Similarly, if a car is moving such that it would cover a distance of 45 miles in one hour, we say its speed is 45 miles per hour (written as 45 mph).

If you measured the distance moved by an object and also the amount of time it took to move that distance, how do you think you could use these two measured values to calculate the object's speed? (For example, if a ball moved 150 centimeters in 3 seconds, how could you use these values for distance and time to calculate how far the ball would move in one second?)

Making Sense

Your teacher will lead a class discussion about how to use distance and time to calculate the speed of an object. Write answers to the following questions after each one is discussed by the class.

1. If you know the distance an object moves and the amount of time it takes to move that distance, how can you use these values to calculate the object's speed?

2. Describe, in words, what the speed of an object tells you about its motion. For example, if the speed of a ball is 75 cm/s, what does this mean?

3. You are going on vacation to a beach that is 300 miles from your home. What speed would you need to have to complete the trip in 6 hours?

4. In the 2008 Olympics Usain Bolt ran the 100 m race in 9.69 seconds. What was his speed?

5. Calculate the speed of the ball you rolled in each of the four runs you made earlier in this activity.

RUN 1: Distance = _____, Time = 2 seconds

Speed =

RUN 2: Distance = _____, Time = 2 seconds

Speed =

RUN 3: Distance = 200 centimeters, Time = _____

Speed =

RUN 4: Distance = 200 centimeters, Time = _____

Speed =

In which of the four runs did the ball have its greatest speed?

Exploration #3: Are all changes in motion the same?

Purpose

You have seen that pushing on a rolling ball will change its motion in some way (its speed, its direction, or both). But are all changes in motion the same? When an object's speed or direction changes, does it always do so in the same way?

In this *Exploration* activity we will examine whether any push on an object will give the same change in its motion.

Are all changes in motion the same, or can they happen in different ways?

What do we think?

Imagine that a player kicks a soccer ball that is rolling across the ground. Would the motion of the ball change in the same way, no matter what the kick was like, or could the motion change in different ways?

Discuss with your neighbors. Do you think the change in the ball's motion would depend on what the kick was like, or would the change be the same, no matter what the kick was like? Why do you think so?

Your teacher will lead a discussion about this question

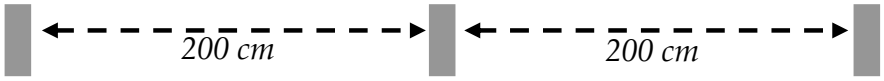
Activity 1: How much does the speed change?

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

- Ball (such as basketball or soccer ball)
- Meter ruler
- 2 stopwatches
- Masking tape

STEP 1: Your group's first task it to see how the speed of a rolling ball changes when it is given different strength 'forward' pushes. To do this you will roll a ball a total distance of 400 cm, but give it a push at the halfway point. You will measure the speed of the ball separately over the 200 cm distances it moves before and after being given a push.

- Stick three small pieces of tape on the floor spaced as shown below.



- Start the ball rolling from the first tape. When the ball reaches the middle tape, one of the group should give it a quick but firm push from behind, in the same direction as its motion, so that it rolls to the third tape
- One stopwatch should be used to measure how much time the ball takes to move the 200 cm from the first to the second piece of tape. The other stopwatch should be used to measure how much time the ball takes to move the 200 cm from the second to the third tape.

Write down how much time it took the ball to roll the 200 centimeter distance before it was given a push. Use the distance and time to calculate the ball's speed.

Time to move 200 cm BEFORE push: _____

Speed BEFORE push:

 Write down how much time it took the ball to roll the 200 centimeter distance after it was given a push. Use the distance and time to calculate the ball's speed.

Time to move 200 cm AFTER push: _____

Speed AFTER push:

STEP 2: You should now repeat this experiment in the following way.

- Start the ball rolling from the first tape at about the same speed as you did in STEP 1.
- At the second tape, make sure the push applied to the ball is again quick, but notably harder than in STEP 1.
- Again, use the two stopwatches to measure how much time it took for the ball to move the 200 cm distances between the tapes.

 Write down how much time it took the ball to roll the 200 centimeter distance before it was given a push. Use the distance and time to calculate the ball's speed.

Time to move 200 cm BEFORE push: _____

Speed BEFORE push:

 Write down how much time it took the ball to roll the 200 centimeter distance after it was given a push. Use the distance and time to calculate the ball's speed.

Time to move 200 cm AFTER push: _____

Speed AFTER push:

STEP 3: In STEPS 1 and 2 you measured the speed of the ball before and after it was given different strength 'forward' pushes.

Did the speed of the ball change by the same amount in both STEPS? If not, in which STEP did the speed change by a larger amount?

Activity 2: How much does the direction change?

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

- Ball (such as basketball or soccer ball)
- Meter ruler
- Masking tape

STEP 1: Your group's next task it to see how the direction of a rolling ball changes when it is given different strength 'sideways' pushes.

- Remove one of the pieces of tape from the floor, so you are left with two pieces that are 200 cm apart.
- Start the ball rolling from the first piece of tape. When the ball reaches the second piece of tape, one member of the group should give it a quick, but gentle, push from the side.
- Another group member should note what direction the ball is moving in after this push and mark it with a new piece of tape on the floor.

You should now repeat this experiment but make sure the sideways push applied to the ball is notably harder than in the previous trial.

- Again, another group member should note what direction the ball is moving in after this push and mark it with another new piece of tape on the floor.

STEP 2: The diagram below shows the direction of the ball as it moved from the first to the second tape.

Draw dashed lines on this diagram to show the direction of the ball after the "sideways" pushes you gave it in STEP 1. Label your lines "Gentle Push" and "Harder Push" as appropriate.

Did the direction of the ball change by the same amount for both pushes? If not, for which push did the direction change the most?

Making Sense

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

1. You know that pushes can change the motion of an object, but are all changes in motion the same? Can the motion of an object change by a different amount?

2. What is it about a push that affects how much the motion of an object changes? What evidence from this *Exploration* supports your thinking?

3. From a standing start, a sports car can reach a speed of 60 mph in 3.5 seconds, whereas it takes a small compact car 11 seconds to reach 60 mph.

   a) Both these cars start and end at the same speed (0 mph and 60 mph), but are their motions changing in exactly the same way? If not, what is different about them?

   b) Why do you think the sports car can reach a speed of 60 mph in a much shorter time than the compact car?

Unit 1 Cycle 2

Application: How do falling objects move?

Purpose

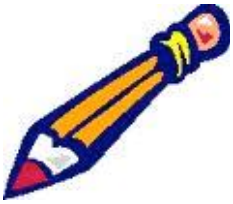
In this Cycle you have examined the motion of objects moving across the ground and how that motion can change. But how do objects move as they fall toward the ground?

For example, if you were to drop a small ball from your hand, what do you think would happen to its speed as it falls? In this *Application* activity you will use your ideas to examine the motion of an object as it falls toward the ground.

How do objects move as they fall?

What do we think?

Hold your pencil above the table/desk. Now let go of it and watch it as it falls.



Do you think the pencil's speed was changing as it was falling (before it hit the table) or do you think its speed stayed the same as it fell? Why do you think so?

Discuss with your neighbors how you could check whether the speed of a falling object stayed the same, or changed, as it fell. Write any ideas you have below.

Your teacher will lead a discussion about falling objects.

Activity: Does the speed of a falling object change, or stay constant?

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

- Tennis ball (or similar)
- 2 meter rulers
- Stopwatch

STEP 1: First you will measure how long it takes a ball to fall a distance of one meter.

- One of your group should hold the ball exactly 2 meters above the floor, ready to drop it. (The group member doing this will likely have to stand on a chair. Please be careful!)
- A second group member should hold their hands, palms flat and facing upward, 1 meter directly below the ball (which is 1 meter above the floor). This person will NOT catch the ball, but just let it hit their hands as it falls.
- Yet another group member should be ready to operate the stopwatch.
- A fourth group member should countdown '3-2-1-GO', at which point the ball should be dropped and the stopwatch started.
- The group member operating the stopwatch should stop it at the moment the ball touches the person's hands that are one meter below where it started.

It will only take a short time for the ball to reach the hands, so the whole group should practice doing this several times, to make sure they are working well together.

 When the whole group is happy that they know what to do, perform the experiment one more time, and record your result below

Our group's time for dropped ball to fall 1 meter: _____

STEP 2: Your teacher will record and display each group's result.

 Is each group's result exactly the same? Why do you think this is?

 Your teacher will lead a discussion on this question, what the best value to use would be, and then calculate what the average of all the group values is.

 Write down the class average time for the ball for fall 1 meter.
Class average time for dropped ball to fall 1 meter: _____

STEP 3: You now know how long it takes a dropped ball to fall a distance of 1 meter. Now suppose that, instead of stopping the ball after it has fallen 1 meter, you allowed it to fall 2 meters, and so reach the floor.

 If the speed of the ball stays constant as it falls, how long do you think it would take it to fall 2 meters, compared to the time it took to fall 1 meter?

 If the speed of the ball increases as it falls, how long do you think it would take it to fall 2 meters, compared to the time it took to fall 1 meter?

If the speed of the ball decreases as it falls, how long do you think it would take it to fall 2 meters, compared to the time it took to fall 1 meter?

Your teacher will lead a discussion on these questions.

STEP 4: Now you will measure how long it takes a ball to fall to the floor from a height of 2 meters.

- Repeat the experiment you did in STEP 1, but this time let the ball fall all the way to the floor without anyone's hands in the way.
- In this case the stopwatch should not be stopped until the moment the ball touches the floor.

When you are happy that your group has performed the experiment correctly, record your group's result below

Our group's time for dropped ball to fall 2 meters: _____

Your teacher will record all the groups' results and again calculate the average value.

Write down the class average time for the ball for fall 2 meters.

Class average time for dropped ball to fall 2 meters: _____

Is the time it took the ball to fall 2 meters, less than, about equal to, or more than double the time it took to fall only 1 meter?

What does this result tell you about the speed of the ball as it was falling? Was it getting faster or slower, or did its speed remain constant?

Making Sense

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

1. What happens to the speed of an object as it falls? Does it increase, decrease, or stay constant? How do you know?

2. A cat knocks a small wooden block off a low coffee table (50 cm high) and the block lands on John's bare foot. John picks the block up and puts it on the dining table (80 cm high), but the cat knocks the block of there too, and again it lands on John's foot.

   In which case would the block hurt John's foot more; when it fell from the coffee table, or when it fell from the dining table? Explain your thinking.

3. You have seen what happens to the speed of an object as it falls. What does this tell you about whether another object is affecting it as it falls? Explain how you know.