Module 4.1

Forces and Motion
What makes objects move the way they do?

CT Science Framework Topics

Forces and Motion – What makes objects move the way they do? ***4.1 - The position and motion of objects can be changed by pushing or pulling*.** ♦ The size of the change in an object's motion is related to the strength of the push or pull. ♦ The more massive an object is, the less effect a given force will have on its motion.	**B 8.** Describe the effects of the strengths of pushes and pulls on the motion of objects. **B 9.** Describe the effect of the mass of an object on its motion.
Energy Transfer and Transformations – What is the role of energy in our world? ***4.4 - Electrical and magnetic energy can be transferred and transformed.*** ♦ Magnets can make objects move without direct contact between the object and the magnet.	**B 14.** Describe the properties of magnets, and how they can be used to identify and separate mixtures of solid materials.

Note: This module (4.1) primarily addresses CT Science Framework 4.1 Forces and Motion. However, one lesson introduces the concept of magnets (CT Science Framework 4.4) as a force that can move objects. Another module (4.4) will address energy transfer and transformations in depth.

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Module 4.1
Forces and Motion

The following are DRAFT Connecticut State 'Grade-Level Expectations'.

GRADE-LEVEL CONCEPT 1: ◆ The size of the change in an object's motion is related to the strength of the push or pull.

GRADE-LEVEL EXPECTATIONS:

1. An object is in motion when its position is changing. Speed describes how far an object moves in a given amount of time (for example, centimeters per second).
2. A force is a push or pull that can cause an object to start moving, stop, or change speed or direction.
3. The greater the force, the greater the change in motion. For example, two people pushing a wagon can get it up to a certain speed faster than one person alone.
4. Changing the force applied to an object, and keeping the mass the same, has measurable effects on the motion of the object.
5. When an object does not move in response to a push or a pull, it is because other equal-sized forces are counteracting the push or pull. Friction (the force between two surfaces) is a force that works against motion.

GRADE-LEVEL CONCEPT 2: ◆ The more massive an object is, the less effect a given force will have on its motion.

GRADE-LEVEL EXPECTATIONS:

6. The amount of force needed to change an object's motion is related to the object's mass.
7. The greater the object's mass, the greater the force needed to start it moving, stop it or change its speed or direction.
8. An object with a small mass is easier to stop or cause a change in motion than an object with a large mass.
9. Adding mass to an object, and keeping the applied force the same, has measurable effects on the motion of the object.

KEY SCIENCE VOCABULARY: motion, force, speed, gravity, friction, mass

MODULE 4.1 FORCES & MOTION

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GLOSSARY AND BACKGROUND

Acceleration: Speed and acceleration are not the same thing. Speed is the ratio of distance traveled over time taken to travel. Speed is measured in meters per second. ("Miles per hour" is another measure of speed). Acceleration is a measure of how rapidly we change our speed. When cars quote the zero to sixty time they are expressing their acceleration. Going from 3 meters per second to 8 meters per second in 2 seconds is an acceleration of $(8-3)/2 = 5/2 = 2.5$ meters per second per second.

Balance: If the forces in one direction are matched by forces of the same strength acting back in the opposite direction, then the forces balance. The motion of an object will not change if all the forces are balanced. When you can hold an object still in your hand, the forces balance.

Energy: is an amount of activity in things. Or, like in a stretched rubber band, the energy is stored, ready to make activity. Stored energy is termed 'potential energy', energy of motion is termed 'kinetic energy', the energy associated with temperature is often called heat or internal energy. Work is the energy that is going from one place to another. Money is a good analogy for energy. All the coins and bills in a room could be traded between students and the total in the room will remain the same. Same with energy, it can be transformed to other forms but the total never changes. The most useless form of energy is heat. It is difficult to get much of that energy to do anything useful. If you account for the amount of money in bank accounts and wallets you are measuring the analogy of energy, But if you keep an accounting of your expenditures and your income you are doing the analogy of measuring work. The unit for both Work and Energy is the Joule.

Force: a push, pull, or other action between two objects. Forces can be large, small, and in between. Forces can make objects move and can change the objects movement. There is always a direction to a force. If you push or pull you must do so in a direction. Blowing on something produces a force. The following are forces: weight (the force of gravity), friction, pushing, pulling, tension (pulling in a rope or string), magnetic force, electrostatic force (the force of 'static cling'). The unit of force is the Newton.

Friction: is a force that slows an object down, stops an object from moving, or pushes back when an object tries to slide. Friction turns energy of movement into heat.

Gravity: The theory describing the pulls between objects due to their mass. **Weight** is the force of gravity and is proportional to mass. Note a heavy object does not run down a slope faster than a less heavy object because while the forces are larger, so is the mass (the inertia or reluctance to accelerate).

Inertia: Objects keep going by themselves. To slow or stop a moving object we need a force. Friction often does this for us. The moon is a good example of an object moving by itself because there is very little friction slowing it down.

Level: (Horizontal) A surface is level when it is flat and horizontal. Water when left undisturbed will form a level surface. A ball on a level surface will stay where it is placed.

Magnet: Objects that can exert magnetic forces on each other and on some other objects are called magnets. The magnetic force, like weight, acts across a space and does not require contact. Magnets can both push and pull. Weight can only pull.

Mass: The more mass the more difficult it is to move or change the motion. Shake an object side to side and you will get a feel for the amount of mass. Mass is proportional to weight, but mass is not the same thing as weight. The mass does not change when an object is moved to another location, such as from the surface of the earth to the moon. If you throw and spin an object, such as a cheerleader's baton or a pencil with a heavy eraser, it will spin about its center of mass, not the middle of its length.

Movement: A movement is something changing its position.

Position: Where something is. A moving object keeps changing its position.

Speed is a measure of how quickly something changes its position. A force is needed every time an object changes its speed. Friction is often changing (slowing) an objects motion. If there is no friction then an object can keep its speed with no force.

Inquiry Lesson 4.1.1 EXPLORING POSITION AND MOTION

Concepts	*Performance Expectations(Objectives)*
Forces and Motion – What makes objects move the way they do? **4.1 - The position and motion of objects can be changed by pushing or pulling**. ♦ The size of the change in an object's motion is related to the strength of the push or pull.	**B 8.** Describe the effects of the strengths of pushes and pulls on the motion of objects. [*The purpose of this lesson is to explain what makes objects start and stop moving, and how they move the way they do.]*

Science Materials: Racquet Ball, Low mass ball, 4 papers inscribed with a circle, 4 drinking straws, stack of post-it notes 3cm high, 1.5cm (½ inch) ring-binder.
Student Handout 4.1.1: *Exploring Motion and Position*
Vocabulary: force, motion (movement), position, slope, direction
Optional Vocabulary and Concepts for Further Exploration: gravity, inertia

Inquiry: In this lesson, students will explore what makes objects start and stop moving by conducting three inquiry tasks. Students will attempt to make a racquet ball rest inside a circle for five seconds, by exerting forces (blowing into straws). They will try this experiment on a flat surface, on a steep slope (the 3-ring binder), and a less steep slope (the 3-ring binder with a book inside to adjust the slope). They will try again using a different ball and they should notice the way that it is easier to change the movement of the lower mass ball.

Procedures and Directions: Provide the students with **Handout 4.1.1** *Exploring Motion and Position,* and the kit 4.1.1. After providing directions and modeling, as appropriate for your class, assign the inquiry tasks to groups of students. Students should record their observations (data) as they conduct the experiment tasks. Students could also be asked to draw a diagram to show what they did and what happened. After the experiment, discuss the students' data and ask guiding questions (see below).

Questions to Guide Student Inquiry

1. How did you get the racquet ball to move?
2. How did you get the racquet ball to stay in the circle?
3. Which task was most difficult and why do you think so?
4. How can you make the racquet ball move faster or slower?
5. Why do you think objects move?
6. Can a ball move when we are not blowing on it?
7. What is motion (movement)?
8. In what way (direction) do objects move?

Science Concepts: Through inquiry, students should be guided to articulate that objects cannot start to move by themselves. They need a ***force*** to push or pull them before they can start or stop moving. Help students understand that it takes more force to make things start or stop quickly. Guide students to state that they had to exert a force (blow into the straw) to move the ball, but once the racquet ball began to move, it tended to keep moving. Guide students to understand that they also had to exert a force (blow into the straw) to keep the ball at rest in the circle when the circle was on a slope. Guide students to observe that the ball moved in a straight path when there was no force acting on it. Movement is a change in position.

Application Problems 4.1.1 Name ....

Date ....

Exploring Position and Motion

Which of the following is true about how all objects move?

a) Objects need a force to push or pull them before they can start or stop moving
b) Objects cannot move in a straight line, when pushed by a force
c) Objects can be moved up a steep slope with very little force
d) It takes more force to keep objects moving than to start them moving

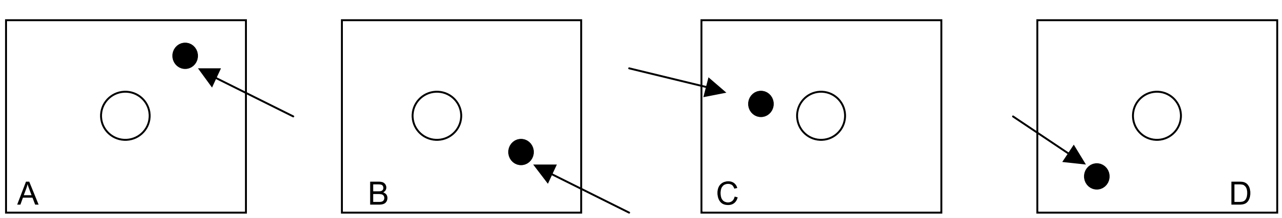
A child is cycling on flat ground and then cycles up a hill. Part way up she stops to talk to a friend and then starts riding up the hill again. Which of these requires the most force and which requires the least? Explain why you think so.

flat, level ground
continuing up hill
starting up hill from a stop

You are studying in the library on a warm day. The librarian turns the fan on the high speed and the pages of your report fly quickly across the room. Which of the following could happen if the librarian turns the fan on the lowest speed?

a) There would be no difference; the papers would blow just as quickly across the room.
b) The papers would blow into the fan
c) The papers would blow slowly away from the fan
d) Other objects such as paper clips and cups would fly across the room

The black dot represents a ball that is not moving. Which of the diagrams shows the correct way to blow to move the ball to make it start moving towards the central circle? Mark all correct choices.



 Exploring Position and Motion Name ....

Date ....

Level your table:
Place the blue Racquet ball on the table, hold it still, and let go.

If the ball stays still, then your table is already level. (If you can rock your table, then find the leg that is off the ground when the ball stays still. Fill the gap below the leg with a stack of post-its.)

If your ball rolls by itself, then lift the corner of the table that it rolls towards until the ball does not roll towards or back away from that corner. Fill the gap below the leg with a stack of post-its.

If the ball rolls towards one of the other corners, then lift that leg until the ball stays put. Fill any gaps you see under the legs with post-it notes. Your table should now be level.

Task 1: Place the paper circle flat on the table. Place the racquet ball on the table next to the paper. You will try to keep a racquet ball inside a circle, but you may not touch the ball with your hands or any other objects. By blowing into the straws, try to move the ball inside the circle and keep it there for five seconds.

After you have succeeded in moving the ball into the circle and keeping it there, record your observations below to show how you accomplished the task:

Where did you place (position) the ball? ....off the paper, outside of the circle....................

How did you start the ball moving? ....force, blow, push with air..

In which direction did the ball move? ....in the direction we blew.......................................

How did you make the ball stay in the circle? ......push from all sides , or not blowing at all.....

....

Record some data. One student in your group be the recorder.

Your ball probably moved all over the place. Choose a few places that it went and mark them on the paper with an x. (Four different places would be good.)

For each mark draw an arrow showing the direction you blew. (If you want you can put the ball back at that place and experiment to see which way you have to start blowing.) You will be drawing the direction of your force.

Label the paper you used “Task 1.”

Task 2: Place the binder on a table, so that the binder makes a hill or a slope. Place a new paper circle on top of the binder. Place the racquet ball in the circle.

By blowing into the straw, try to keep the ball inside the circle without touching it. Try to keep it there for one second. Try doing this for about 3 minutes.

After you have tried, record your observations below to show how you accomplished your task:

In which direction did the ball move? ....down hill, or in the direction of a hard blow, or in

some combination of the two……

How did you try to make the ball stay in the circle? ....blow against the force from the slope......

....

Record some data.

Mark on the paper several places (positions) where the ball went. For each position draw an arrow showing the direction you blew (this is the direction of your force.)
Label the paper you used "Tasks 2 and 3."

Task 3: Put a book inside the binder so that the slope is not as steep as in Task 2. Place the racquet ball in the circle.

By blowing into the straw, try to keep the ball inside the circle for one second. You may not touch the ball. After you have succeeded in keeping the ball in the circle, record your observations below to show how you accomplished the task:

In which direction did the ball move? ....down hill but not as strongly / quickly.........

How did you make the ball stay in the circle? ....blowing against the slope.....................

....

Mark on the paper several places (positions) where the ball went. For each position draw an arrow showing the direction you blew. This is the direction of your force.

Task 4: Take the lower mass ball and use it to perform task 3. Describe what has changed.

………It is easier (less force) to blow this light weight ball, slope seems not as strong………

Circle the words to complete the sentences describing what you observed.

To start an object moving very quickly, push (or blow) it **gently / moderately / <u>strongly</u>** .

To start an object moving not as quickly, push (or blow) it **gently / <u>moderately</u> / strongly** .

To start an object moving very slowly, push (or blow) it **<u>gently</u> / moderately / strongly** .

<u>Some questions to think about and answer:</u>

Which task was most difficult and why do you think so? ....

.blowing the heavier ball up the steeper slope,

because gravity and the slope produced a strong force ....

What do you think makes objects start moving? .....a force, or unbalanced forces..................

Describe what you observed that shows this. ....ball stayed still on the flat horizontal desk...

....

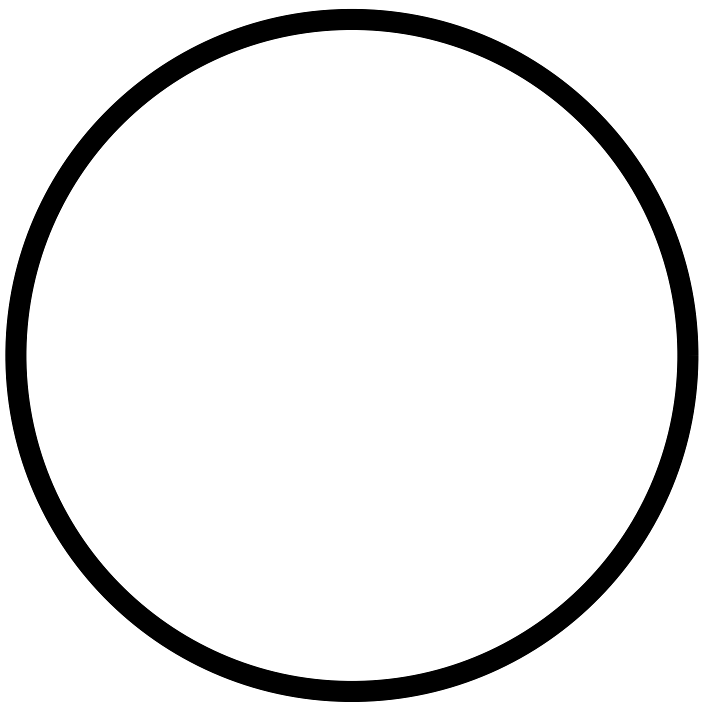
What do you think makes objects stop moving? ....a force or unbalanced forces, friction......

Describe what you observed that shows this. ......if the ball was coming towards me I had to blow to stop it and turn its motion around...

What do you think makes objects change its movement? .....force...

Describe what you observed that shows this. ....blowing, slopes, gravity, pulling, pushing, all change movement...

Lesson 4.1.1 Task Set Up



Inquiry Lesson 4.1.2 EXPLORING WHAT MAGNETS CAN DO

Concepts	*Performance Expectations(Objectives)*
Forces and Motion – What makes objects move the way they do? **4.1 - The position and motion of objects can be changed by pushing or pulling**. ♦ (**4.4**) Magnets can make objects move without direct contact between the object and the magnet.	**B 9.** Describe the effects of the strengths of pushes and pulls on the motion of objects. [*The purpose of this lesson is to identify magnets as a force that can move objects without touching them.]*

Science Materials (for each group of students): 2 Bar Magnets, 4 paper clips, string (40cm), 1 ruler, 2 plotting compasses
Vocabulary: magnet, magnetic force, north pole, south pole, attraction (pull), repulsion/repel (push)

Inquiry: In this inquiry task, students will try to make a standing magnet fall by using magnetic force; they will try to make the standing magnet fall without touching it with the second magnet. They will also try to move paper clips with magnetic force. In another task, students will discover that magnets move the hands of a compass, by moving the magnet near the compass without touching it.

Procedures and Directions: Provide the students with **Handout 4.1.2** *Magnetic Forces Move Objects* and the kit 4.1.2. After providing directions and modeling, as appropriate for your class, assign the inquiry tasks to groups of students. Students should record their observations (data) as they conduct the experiment tasks. After the experiment(s), discuss the data collected and guide students to articulate the science concept through questioning and analysis of the data they collected.

Questions to Guide Student Inquiry

1. How did you make the magnet fall?
2. When did the string hang to the side?
3. Why did the string hang to the side?
4. Does changing the string length change what happened?
5. How did you move the paper clips?
6. What do your observations tell you about the strength of magnets?
7. Are magnets forces?
8. How does a compass work? What makes the hands of a compass move?
9. What conclusion can you draw about magnetic forces and movement?

Science Concepts: A magnet produces forces that can move some objects without contact. A magnet can push (repel) and pull (attract) another magnet. Magnetic forces, like other forces, can change the amount and direction of an object's movement.

Application Problems

Lesson 4.1.2

Exploring What Magnets Can Do

These assessment items are intended to provide closure for each lesson and help teachers determine how well the students understand the science concepts. The assessments are also intended to provide students additional practice with the lesson content. Teachers should use the assessment items as they deem appropriate. For example, teachers may wish to assign them for homework, assign them as an additional class activity or "quiz" at the end of a lesson, or ask students to answer them individually as they leave the class (as "exit passes"). Teachers may wish to use the problems as a closing class activity, asking students to solve the problem in groups and then share their answers in a whole group closing activity.

1. A science class magnet can pick up a paperclip. Explain why a refrigerator magnet can not pick up a refrigerator. The force of the magnet is too small, much smaller than the weight of the refrigerator

2. Label each of the following "True" or "False." Explain why you think so.

True False A magnet can pull on a paper clip.
True False A paperclip can pull on a magnet.
True False A magnet can push on a paper clip. Warning, these may be true in the rare case that the paperclip has been magnetized and that the regular magnet has not changed the magnetic direction in the paperclip. You may see a weak repulsion.
True False A paperclip can push on a magnet.
True False A magnet can pull on a magnet.
True False A magnet can push on a magnet.

2. Which is true about a magnet?
a) A magnet is a force False
b) A magnet is an object True
c) A magnet can move another magnet without touching it True
d) A magnet can move the hands of a compass True
e) b, c and d True
f) all of the above False

Handout 4.1.2 (page 1/2) ***Exploring What Magnets Can Do*** Name ....

Date ....

Task 1: Stand one magnet on end on the table.
Tie a string to one end of the other magnet.
Use the hanging magnet to make the standing magnet fall over.

Do not let anything touch the standing magnet.
Do not touch the hanging magnet with your hands.

When does the string hang nearly straight down? (Ignore small movements.) ....

..........When the magnets are far apart........small force between them..........................

When did the string hang at an angle? ......when the magnets were close, there was a larger force between them...

What made the string hang at an angle? ....The force on the hanging magnet from the other magnet...

What did you do to make the standing magnet fall? .....pulled the hanging magnet close to it....

....

What happens when you stand the magnet up on its other end? ....in one case there is a pull (attraction) between the magnets, in the other there is a push (repulsion) between them.

Task 2: Hold the bottom of the standing magnet. Lower the other magnet by its string.

Can you get the magnets to touch? Circle Yes or No Depends on the N/S orientations

Turn over the standing magnet and try again. Can you get these ends to touch? Yes or No
Opposite choice to above

Describe what happened when you could not get the magnets to touch. …………………………

………Repulsion, difficult to keep the hanging magnet in one position, repulsion acts all the way around pointing away from the standing held magnet.
……………………………………………………………………………………………..

Task 3: Stand one magnet on end on the table. Hold the other magnet in your hand. Hang one paper clip or a chain of paper clips from your magnet. Use the hanging paper clips to make the standing magnet fall over. The paper clips may touch the standing magnet.

How did you accomplish this task? .....by letting the paper clip act as a go between...............

Handout 4.1.2 (page 2/2)

Task 4. Place the compass on the table. Do not touch the compass with your hands or the magnet. Try to make the hands of the compass move.

What do you think makes the hands of the compass move? ....Magnetic force..................

Considering what you observed in all these science tasks, write two facts about magnets.

(1).........Attract Repel Force over a distance......................................

....

(2)..

....

Complete this sentence using two pieces of evidence from your experiment.

I know there was a force when I saw (1) ..the magnet fall......................................

....

and when I saw (2) ....the string at an angle...

....

....

Complete this sentence. The force from the magnet was stronger when ……………………

...........the magnets were closer togeter..

....

Do you think the two ends of the magnet are the same? Circle yes or no.

Describe some evidence from your experiment supports your answer. ....

.................Turning one of them over made a difference when both magnets were used.......

....

Inquiry Lesson 4.1.3 **SLOW DOWN!**

Concepts	*Performance Expectations(Objectives)*
Forces and Motion – What makes objects move the way they do? **4.1 - The position and motion of objects can be changed by pushing or pulling**. ♦ The size of the change in an object's motion is related to the strength of the push or pull.	**B 8.** Describe the effects of the strengths of pushes and pulls on the motion of objects. *[The purpose of this lesson is to explain the effect of friction on an object's movement.]*

Science Materials (for each group of four students): 1 racquet ball, 1 half-inch ring binder, fabric without seams about 60 x 30 cm, 4 drinking straws
Student Handout 4.1.3 *Slow Down!*
Vocabulary: friction, friction force, surface

Inquiry: In this lesson, students will test the effect of friction on the movement of the ball by watching its speed as it rolls down a slope covered with various thicknesses of cloth.

Procedures and Directions: Assign students to groups of four. Have the students put the ring binder on the table to act as a slope. The experiment involves covering the slope with one, then two, then four and more layers of cloth. This is done by folding and refolding the cloth. The students should notice that the speed with which the ball rolls down the slope depends on the thickness of the cloth. In the second part of the experiment they can help the ball to move by blowing on it, and they can slow it further by blowing against it. **You may want to make a graph of speed vs. cloth thickness using their data.**

Questions to Guide Student Inquiry

1. When did the ball move the fastest? The slowest?
2. Why do you think this happened?
3. What other examples of friction do you see around you?
4. How can you use the straw to make the ball slow down?
5. How can you use the straw to make the ball speed up?
6. Describe three forces in this experiment. (from the slope, friction, weight, and blowing.)
7. How do you know that forces can have different strengths?

Science Concepts: Friction slows down a moving object. The harder and more slippery the surface, the less friction. The rougher and softer the surface, the more friction. Friction produces a force, the friction force. In this experiment the slope, the friction, the ball's weight, and the blowing are all forces.

Because there is friction in all of our living experiences many of us incorrectly think that everything naturally slows down and stops. If there is no friction objects actually keep moving forever or until some other force acts on them; whichever comes first. You will often need *both* ideas to explain events.☺

Application Problems

Lesson 4.1.3

Slow Down!

These assessment items are intended to provide closure for each lesson and help teachers determine how well the students understand the science concepts. The assessments are also intended to provide students additional practice with the lesson content. Teachers should use the assessment items as they deem appropriate. For example, teachers may wish to assign them for homework, assign them as an additional class activity or "quiz" at the end of a lesson, or ask students to answer them individually as they leave the class (as "exit passes"). Teachers may wish to use the problems as a closing class activity, asking students to solve the problem in groups and then share their answers in a whole group closing activity.

1. Mary and her friends are trying to move heavy furniture from the living room into the family room. The living room is carpeted and the family room has a tile floor. In which room will it be easier to slide the furniture? Explain why you think so. Use at least one scientific term in your explanation.

Friction is stronger on the carpet than on the tile floor.

2. If you are riding your bicycle on flat level ground and stop peddling, which of the following is true?
   a) You keep going at the same speed because there is no force to slow you down
   b) You keep going at the same speed because the bike has a natural speed on flat ground
   c) You speed up because you had been pedaling before
   d) You speed up because you want to speed up
   e) You slow down because everything always slows down Warning not true
   f) You slow down because friction is a force slowing your bike True

Handout 4.1.3 (page 1/2) ***Slow Down !*** Name ....

Date ....

Task 1: Put the ring binder on its side on the desk. Put the ball on the slope made by the binder. Let go of the ball and watch the ball roll down the slope. In the first part of this experiment you must **not** blow on the ball. You must simply release the ball on the slope; you may **not** start with a moving ball. Once you have watched the ball rolling down the slope follow the directions below, adding layers of cloth to the experiment.

Spread one layer of the cloth over the slope and watch the ball roll down the slope.

Keep adding layers of cloth by doing the following:
Fold the cloth in half and spread two layers of cloth over the binder. Roll the ball again.

Fold the cloth in half a second time producing four layers and roll the ball.

Fold the cloth in half a third time and roll the ball. Notice how many layers of cloth you have.

Circle the number of layers of cloth for the **fastest** slope.

0 1 2 3 4 5 6 7 8 9

Circle the number of layers of cloth for the **second fastest** slope.

0 1 2 3 4 5 6 7 8 9

Circle the number of layers of cloth for the **third fastest** slope.

0 1 2 3 4 5 6 7 8 9

Circle the number of layers of cloth for the **fourth fastest** slope.

0 1 2 3 4 5 6 7 8 9

Circle the number of layers of cloth for the **fifth fastest** slope.

0 1 2 3 4 5 6 7 8 9

Task 2: Put a few layers of cloth on the slope. (You can choose how many layers). Run the ball down the slope and watch how fast it goes.

Blow through the straws so that you can make this ball move faster down the slope.
Blow through the straws so that you can make this ball move slower down the slope.

Based on this experiment, what do you think makes objects slow down?

.........friction and other forces...

....

What other objects have you seen slow down and stop? ....almost everything balls, toy cars, real cars,............................. ………………………………………………

Describe another way to slow down objects?

...........apply force from your hand, blow on it , spiders web, parachute............................

....

.... …………………………………………………………

Friction and some other forces slow things down. The moon keeps going and going and going and going around the earth. What can you conclude about the friction acting to slow down the moon? ....very very very very very small there is no air so almost no friction..........

....................For the teacher's information, there is a little friction in the tides on earth and the moon is slowing down over astronomical time periods (hundreds of thousands of years) ....

…………………………………………………………………………………………………

Inquiry Lesson 4.1.4 **SPEEDING UP WITH MORE FORCE AND LESS MASS**

Concepts	*Performance Expectations(Objectives)*
Forces and Motion – What makes objects move the way they do? **4.1 - The position and motion of objects can be changed by pushing or pulling**. ♦ The size of the change in an object's motion is related to the strength of the push or pull. ♦ The more massive an object is, the less effect a given force will have on its motion.	**B 8.** Describe the effects of the strengths of pushes and pulls on the motion of objects. **B 9.** Describe the effect of the mass of an object on its motion.

Science Materials (for each group): 4 decks of cards
Student Handout 4.1.4 *Speeding Up with More Force and Less Mass*
Vocabulary: force, mass, speed, change in speed

Inquiry: Students will take a few cards from a deck and use one, two, three, or four cards to push the remaining packet of cards. Each card will bend and become useless if it is pushing too hard, so each student will be limited in how hard they can push. The fewer cards, the less force and the more slowly the pack acquires speed. The more cards, the more force and the more rapid acquisition of speed. The students then remove many of the cards from some of the packs thereby producing packs with less mass. The different mass packets are then pushed with nearly equal force and the effect of the mass can be seen. The students should make the connection that the faster packs are those with lower mass.

Procedures and Directions: Assign students to groups of three of four to conduct the experiment tasks. Provide Handout 4.1.4 to each student and one kit 4.1.4 to each group. Share results in a whole group discussion, guided by inquiry questions below.

Questions to Guide Student Inquiry:

1. Can you push as hard as you like when you have to use the cards?
2. Is one card putting more force onto the deck than two cards?
3. Why does having a different number of cards change the amount of force?
4. What makes objects speed up quickly?
5. Do all objects speed up at the same rate when an equal force is applied?
6. If you pushed an object with a small force and it kept going faster and faster, could you use that small force to eventually reach a high speed?

Science Concepts: More force produces greater change in speed. More mass results in less change in speed from the same force. To get a similar rate of change of speed, large mass objects must be driven with a correspondingly greater force than lower mass objects. 'acceleration' is the term for the rate at which we change speed, but this term is not being used at this grade level.

Note and Challenge: Weight is not the same as mass. Note that shaking something side to side has nothing to do with weight.

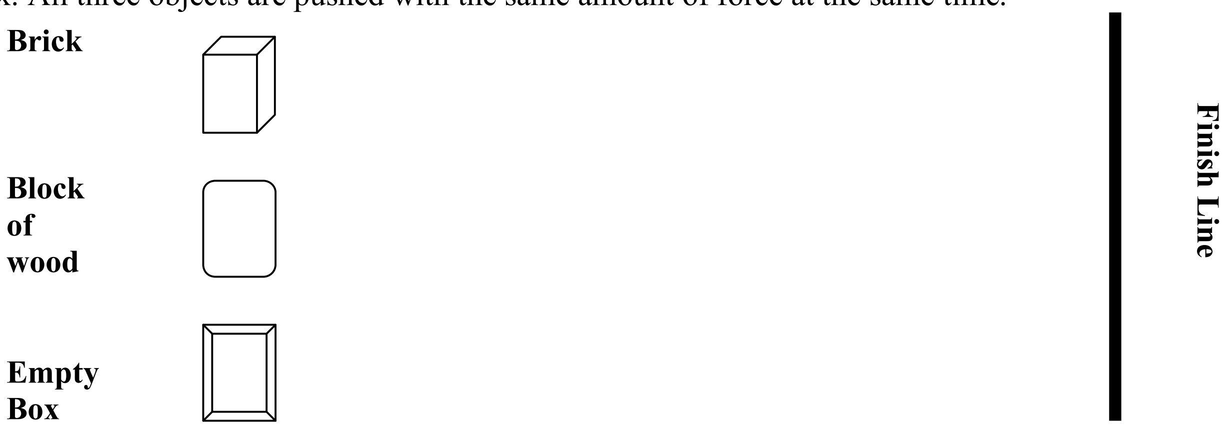
Application Problems
Lesson 4.1. 4 Speeding Up with More Force and Less Mass

These assessment items are intended to provide closure for each lesson and help teachers determine how well the students understand the science concepts. The assessments are also intended to provide students additional practice with the lesson content. Teachers should use the assessment items as they deem appropriate. For example, teachers may wish to assign them for homework, assign them as an additional class activity or "quiz" at the end of a lesson, or ask students to answer them individually as they leave the class (as "exit passes"). Teachers may wish to use the problems as a closing class activity, asking students to solve the problem in groups and then share their answers in a whole group closing activity.

1. You and your best friend are helping with the grocery shopping. You have filled two shopping carts. Cart A is filled to the top with milk, orange juice and cans of vegetables. Cart B is filled with cereal boxes, an inflated beach ball and some bags of chips. The two carts are sitting next to each other when you and your friend decide to race the carts to the end of an isle. Which cart do you choose so that you can move more quickly? Explain how the carts are different even though they are filled to the same level. Cart A has more mass

2.You close your eyes and are given two closed containers of the same size. One container is full of un-popped pop corn kernels and the other is full of popped popcorn. Explain how you can tell which is ready to eat? The popped popcorn is less dense, so in the same volume there will be less mass.

3. The diagram below shows three different objects: a brick, a block of wood, and an empty cardboard box. All three objects are pushed with the same amount of force at the same time.



Which object will reach the finish line first?

a) the brick
b) the block of wood
c) the empty box
d) they will all reach the finish line at the same time

4. Explain why a small mouse can jump quickly away from a big elephant even when the elephant is so strong that it can pull over a big tree. The elephant can produce very large forces, but it also has a very large mass, the weaker mouse has so little mass that it can change its speed very quickly.

Handout 4.1.4 (page 1/2) ***Force, Mass, and Change of Speed*** Name ....

Date ....

Materials:
4 decks of cards

Task 1: Take one deck of cards each. Remove four cards and replace the rest.
Hold that card by pinching the letter or number at the top between your thumb and forefinger.
Push on the box with the bottom flat face of the card. Notice that the card bends.
Now try with a stack of two cards, three cards, and four cards.

Rank the card stacks according to how quickly you could move the box.

It was easiest to move the box using ……four……….. card (s)

It was second easiest to move the box with ……three…………. card (s)

It was third easiest to move the box with ………two……….. card (s)

It was most difficult to move the box with …………one………card (s)

Task 2: Hold one card in the same way as in task 1, (pinching over the letter or number).
Push on the back of your other hand in the same way that you pushed on the box.
Close your eyes and feel how strong the push (force) is.

Repeat the push with a stack of 2, 3, and then 4 cards. Rank the stacks according to how hard they push felt.

The strongest force came from the stack of ……four………….. card (s)

The second strongest force came from the stack of …three………….. card (s)

The third strongest force came from the stack of ……two…………..card (s)

The smallest force came from the stack of ………one………… card (s)

Game. Close your eyes and have another student push on your hand with 1, 2, 3, or 4 cards.
See if you can guess how many cards they used.

Handout 4.1.4 (page 2/2)

Task 3: Work in pairs with one student pushing a pack of cards and the other catching it.

Have two catchers stand next to each other on one side of the desk and their two pushers stand next to each other but on the opposite side of the desk.

One pusher uses **one** card to push with and the other pusher uses **four** cards.

See who can get their cards to the cross the desk and be caught by their catcher the fastest?

Complete these observation statements.

The greatest change in speed occurred when pushing with …four……….. cards.

Less change in speed occurred when pushing with …one………… cards.

For an object to change speed more quickly a **larger** / **smaller** force is needed.

Task 4: Stay in your pairs but switch roles. The pusher becomes the catcher and the catcher becomes the pusher. Both pushers should use **two** cards.

One pusher should take all the cards out of their packet and use the empty container. The other pusher should use their full pack. Before you push them, both the packs should look the same.

See who can get their pack to the cross the desk and be caught by their catcher the fastest?

Complete these observation statements.

The greatest change in speed occurred when pushing the …empty……….. packet.

Less change in speed occurred when pushing the …full………… packet.

We pushed with the same force on two objects but they did not move in the same way.
The object with more mass changed speed **more quickly** / **more slowly** than of an object with less mass.

Write your own conclusion: An object with more material (mass) in it ……………………………

………is more difficult to make move or to stop moving…………………

……………………………………………………………………………………………….

Inquiry Lesson 4.1.5 **MASS and FORCE**

Concepts	*Performance Expectations (Objectives*
Forces and Motion – What makes objects move the way they do? **4.1 - The position and motion of objects can be changed by pushing or pulling**. ♦ The more massive an object is, the less effect a given force will have on its motion.	**B 9.** Describe the effect of the mass of an object on its motion. *[The purpose of this lesson is to explain the relationship between force and mass.]*

Science Materials (for each group): 1 page printed with a target circle, 1 page printed with "Release Position"; ¾ inch three ring binder; four drinking straws; balls with a range of sizes and masses (such as small and large marbles, ball bearing; racquet ball, ping pong ball, golf ball, high bounce ball)
Student Handout 4.1.5 *Mass and Force*
Vocabulary: mass, force

Inquiry: In this inquiry, students will explore the relationship between mass and force by observing how much force it takes to deflect balls of different sizes and masses. The students will be changing the motion by blowing from the side; this is subtly different from starting and stopping, speeding up and slowing down. The students should link the amount of force to the amount of change in the motion. Students should also link the amount of mass to the difficulty of changing the motion.

Procedures and Directions: Provide students with the materials, including the Target and Release Position handouts to set up the task. Students will be rolling different balls from the release position toward the circle. They will then try to stop the balls from crossing the goal circle by blowing at them sideways through straws. Guide students to understand that it takes more force to turn aside the balls that have more mass.

Questions to Guide Student Inquiry
1. Which ball was easiest to turn?
2. Which one was the most difficult to turn?
3. Why do you think so?
4. Do you think that the balls that are difficult to turn are also difficult to stop and start?

Science Concepts: The more mass, the more force is needed to change its motion. The more massive an object is, the less effect a given force will have on its motion. If you blow from the side the ball keeps moving along, but it begins to move sideways too.

Application Problems

Lesson 4.1.5

These assessment items are intended to provide closure for each lesson and help teachers determine how well the students understand the science concepts. The assessments are also intended to provide students additional practice with the lesson content. Teachers should use the assessment items as they deem appropriate. For example, teachers may wish to assign them for homework, assign them as an additional class activity or "quiz" at the end of a lesson, or ask students to answer them individually as they leave the class (as "exit passes"). Teachers may wish to use the problems as a closing class activity, asking students to solve the problem in groups and then share their answers in a whole group closing activity.

Which of the following is most likely to blow away on a windy day?

a) a picnic table
b) a lawn chair
c) a beach ball
d) a barbecue grill

Imagine you are pushing a shopping cart around a grocery store. Compare how it would feel to turn a corner pushing a cart that is full of milk and heavy cans, as opposed to an empty cart.

Heavy Cart	Empty Cart
Sluggish, difficult, hard, heavy, awkward	

Handout 4.1.5 (page 1/1) **Force and Mass** Name ....

Date ....

Set up: Put the three ring binder at one end of the table. Take the circle to the other end of the table. Roll a ball from the marked release position and watch its path. Put the goal circle where the ball went. To check the set up, roll a ball from the marked "release position "so that the ball rolls across circle.
Task: Test each ball by rolling it from the release position. Then release the ball again but now blow through the straws to push the ball sideways so that it does not cross the "goal". If you have succeeded in "saving the goal", the ball will have gone past but not over the circle.
Rule: Do not touch the ball after it is released.

Rank the balls according to whether they are easier or more difficult to keep away from the goal. Put a name and description on each of four balls.

	Name for Ball	**Description of Ball**
Easiest to turn		**low mass (large sail area)**
2nd easiest to turn		
3rd easiest to turn		
Most difficult to turn		**large mass (big steel or glass balls)**

Think about the easiest ball to turn. What is it about this ball that made it easy to turn?

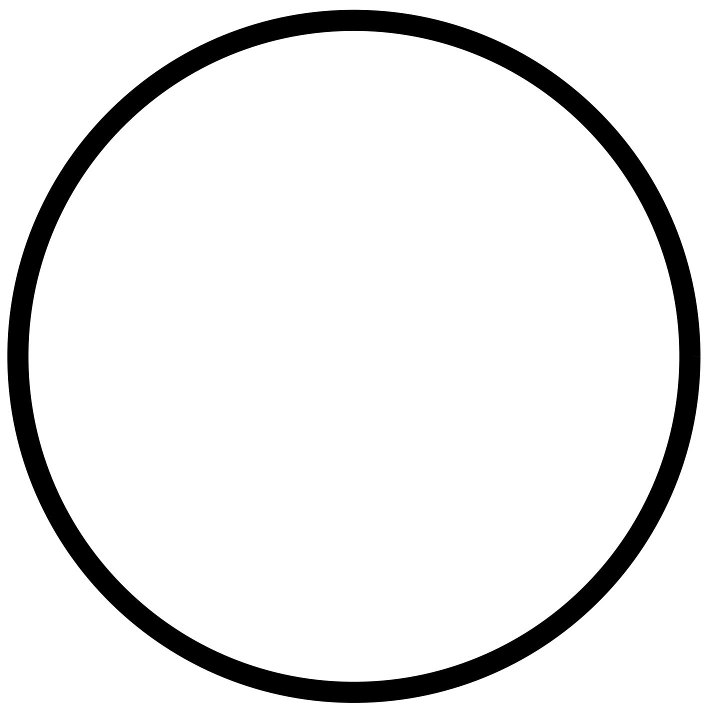
low mass (correlates to low weight, as mass is proportional to weight, but not the same thing.)....

....

Think about the most difficult ball to turn. What is it about this ball that made it difficult to turn?

.......High mass (correlates to weight)..

Lesson 4.1.5 Task Set Up



Lesson 4.1.5 Task Set Up

X release position

 Exploring Position and Motion Name ....

Date ....

Level your table:
Place the blue Racquet ball on the table, hold it still, and let go.

If the ball stays still, then your table is already level. (If you can rock your table, then find the leg that is off the ground when the ball stays still. Fill the gap below the leg with a stack of post-its.)

If your ball rolls by itself, then lift the corner of the table that it rolls towards until the ball does not roll towards or back away from that corner. Fill the gap below the leg with a stack of post-its.

If the ball rolls towards one of the other corners, then lift that leg until the ball stays put. Fill any gaps you see under the legs with post-it notes. Your table should now be level.

Task 1: Place the paper circle flat on the table. Place the racquet ball on the table next to the paper. You will try to keep a racquet ball inside a circle, but you may not touch the ball with your hands or any other objects. By blowing into the straws, try to move the ball inside the circle and keep it there for five seconds.

After you have succeeded in moving the ball into the circle and keeping it there, record your observations below to show how you accomplished the task:

Where did you place (position) the ball? ....

How did you start the ball moving? ....

In which direction did the ball move? ....

How did you make the ball stay in the circle? ....

....

Record some data. One student in your group be the recorder.

Your ball probably moved all over the place. Choose a few places that it went and mark them on the paper with an x. (Four different places would be good.)

For each mark draw an arrow showing the direction you blew. (If you want you can put the ball back at that place and experiment to see which way you have to start blowing.) You will be drawing the direction of your force.

Label the paper you used “Task 1.”

Task 2: Place the binder on a table, so that the binder makes a hill or a slope. Place a new paper circle on top of the binder. Place the racquet ball in the circle.

By blowing into the straw, try to keep the ball inside the circle without touching it. Try to keep it there for one second. Try doing this for about 3 minutes.

After you have tried, record your observations below to show how you accomplished your task:

In which direction did the ball move? .... ………………………………

How did you try to make the ball stay in the circle? ....

....

Record some data.

Mark on the paper several places (positions) where the ball went. For each position draw an arrow showing the direction you blew (this is the direction of your force.)
Label the paper you used “Tasks 2 and 3.”

Task 3: Put a book inside the binder so that the slope is not as steep as in Task 2. Place the racquet ball in the circle.

By blowing into the straw, try to keep the ball inside the circle for one second. You may not touch the ball. After you have succeeded in keeping the ball in the circle, record your observations below to show how you accomplished the task:

In which direction did the ball move? ....

How did you make the ball stay in the circle? ....

....

Mark on the paper several places (positions) where the ball went. For each position draw an arrow showing the direction you blew. This is the direction of your force.

Task 4: Take the lower mass ball and use it to perform task 3. Describe what has changed.

……

……

Circle the words to complete the sentences describing what you observed.

To start an object moving very quickly, push (or blow) it **gently / moderately / strongly** .

To start an object moving not as quickly, push (or blow) it **gently / moderately / strongly** .

To start an object moving very slowly, push (or blow) it **gently / moderately / strongly** .

Some questions to think about and answer:

Which task was most difficult and why do you think so? ....

....

....

What do you think makes objects start moving? ....

Describe what you observed that shows this. ....

....

What do you think makes objects stop moving? ....

Describe what you observed that shows this. ....

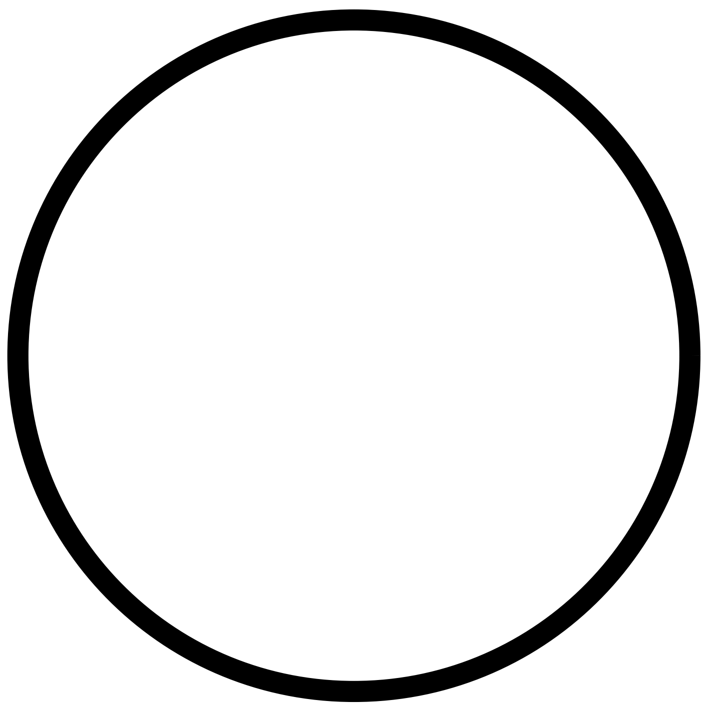
....

What do you think makes objects change its movement? ....

Describe what you observed that shows this. ....

....

Lesson 4.1.1 Task Set Up



Handout 4.1.2 (page 1/2) ***Exploring What Magnets Can Do*** Name ....

Date ....

Task 1: Stand one magnet on end on the table.
Tie a string to one end of the other magnet.
Use the hanging magnet to make the standing magnet fall over.

Do not let anything touch the standing magnet.
Do not touch the hanging magnet with your hands.

When does the string hang nearly straight down? (Ignore small movements.) ....

....

When did the string hang at an angle? ....

....

What made the string hang at an angle? ....

....

What did you do to make the standing magnet fall? ....

....

What happens when you stand the magnet up on its other end? ....

....

Task 2: Hold the bottom of the standing magnet. Lower the other magnet by its string.

Can you get the magnets to touch? Circle Yes or No

Turn over the standing magnet and try again. Can you get these ends to touch? Yes or No

Describe what happened when you could not get the magnets to touch. …………………………

……..

……..

Task 3: Stand one magnet on end on the table. Hold the other magnet in your hand. Hang one paper clip or a chain of paper clips from your magnet. Use the hanging paper clips to make the standing magnet fall over. The paper clips may touch the standing magnet.

How did you accomplish this task? ....

Handout 4.1.2 (page 2/2)

Task 4. Place the compass on the table. Do not touch the compass with your hands or the magnet. Try to make the hands of the compass move.

What do you think makes the hands of the compass move? ....

....

Considering what you observed in all these science tasks, write two facts about magnets.

(1)..

....

(2)..

....

Complete this sentence using two pieces of evidence from your experiment.

I know there was a force when I saw (1) ....

....

and when I saw (2) ....

....

....

Complete this sentence. The force from the magnet was stronger when ……………………

....

....

Do you think the two ends of the magnet are the same? Circle yes or no.

Describe some evidence from your experiment supports your answer. ....

....

....

 Slow Down ! Name ....

Date ....

Task 1: Put the ring binder on its side on the desk. Put the ball on the slope made by the binder. Let go of the ball and watch the ball roll down the slope. In the first part of this experiment you must **not** blow on the ball. You must simply release the ball on the slope; you may **not** start with a moving ball. Once you have watched the ball rolling down the slope follow the directions below, adding layers of cloth to the experiment.

Spread one layer of the cloth over the slope and watch the ball roll down the slope.

Keep adding layers of cloth by doing the following:
Fold the cloth in half and spread two layers of cloth over the binder. Roll the ball again.

Fold the cloth in half a second time producing four layers and roll the ball.

Fold the cloth in half a third time and roll the ball. Notice how many layers of cloth you have.

Circle the number of layers of cloth for the **fastest** slope.

0 1 2 3 4 5 6 7 8 9

Circle the number of layers of cloth for the **second fastest** slope.

0 1 2 3 4 5 6 7 8 9

Circle the number of layers of cloth for the **third fastest** slope.

0 1 2 3 4 5 6 7 8 9

Circle the number of layers of cloth for the **fourth fastest** slope.

0 1 2 3 4 5 6 7 8 9

Circle the number of layers of cloth for the **fifth fastest** slope.

0 1 2 3 4 5 6 7 8 9

Handout 4.1.3 (page 2/2)

Task 2: Put a few layers of cloth on the slope. (You can choose how many layers). Run the ball down the slope and watch how fast it goes.

Blow through the straws so that you can make this ball move faster down the slope.
Blow through the straws so that you can make this ball move slower down the slope.

Based on this experiment, what do you think makes objects slow down?

....

....

What other objects have you seen slow down and stop? ....

.... ……………………………………………

Describe another way to slow down objects?

....

....

.... ………………………………………………………

Friction and some other forces slow things down. The moon keeps going and going and going and going around the earth. What can you conclude about the friction acting to slow down the moon? ....

....

………………………………………………………………………………………………

Handout 4.1.4 (page 1/2) ***Force, Mass, and Change of Speed*** Name ....

Date ....

Materials:
4 decks of cards

Task 1: Take one deck of cards each. Remove four cards and replace the rest. Hold that card by pinching the letter or number at the top between your thumb and forefinger. Push on the box with the bottom flat face of the card. Notice that the card bends. Now try with a stack of two cards, three cards, and four cards.

Rank the card stacks according to how quickly you could move the box.

It was easiest to move the box using …………….. card (s)

It was second easiest to move the box with ………………. card (s)

It was third easiest to move the box with ……………….. card (s)

It was most difficult to move the box with …………………card (s)

Task 2: Hold one card in the same way as in task 1, (pinching over the letter or number). Push on the back of your other hand in the same way that you pushed on the box. Close your eyes and feel how strong the push (force) is.

Repeat the push with a stack of 2, 3, and then 4 cards. Rank the stacks according to how hard they push felt.

The strongest force came from the stack of ……………….. card (s)

The second strongest force came from the stack of …………….. card (s)

The third strongest force came from the stack of ………………..card (s)

The smallest force came from the stack of ………………… card (s)

Game. Close your eyes and have another student push on your hand with 1, 2, 3, or 4 cards. See if you can guess how many cards they used.

Handout 4.1.4 (page 2/2)

Task 3: Work in pairs with one student pushing a pack of cards and the other catching it.

Have two catchers stand next to each other on one side of the desk and their two pushers stand next to each other but on the opposite side of the desk.

One pusher uses **one** card to push with and the other pusher uses **four** cards.

See who can get their cards to the cross the desk and be caught by their catcher the fastest?

Complete these observation statements.

The greatest change in speed occurred when pushing with ………….. cards.

Less change in speed occurred when pushing with …………… cards.

For an object to change speed more quickly a **larger / smaller** force is needed.

Task 4: Stay in your pairs but switch roles. The pusher becomes the catcher and the catcher becomes the pusher. Both pushers should use **two** cards.

One pusher should take all the cards out of their packet and use the empty container. The other pusher should use their full pack. Before you push them, both the packs should look the same.

See who can get their pack to the cross the desk and be caught by their catcher the fastest?

Complete these observation statements.

The greatest change in speed occurred when pushing the ………….. packet.

Less change in speed occurred when pushing the …………… packet.

We pushed with the same force on two objects but they did not move in the same way.
The object with more mass changed speed **more quickly / more slowly** than of an object with less mass.

Write your own conclusion: An object with more material (mass) in it ……………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………….

Handout 4.1.5 (page 1/1) **Force and Mass** Name ....

Date ....

Set up: Put the three ring binder at one end of the table. Take the circle to the other end of the table. Roll a ball from the marked release position and watch its path. Put the goal circle where the ball went. To check the set up, roll a ball from the marked "release position "so that the ball rolls across circle.
Task: Test each ball by rolling it from the release position. Then release the ball again but now blow through the straws to push the ball sideways so that it does not cross the "goal". If you have succeeded in "saving the goal", the ball will have gone past but not over the circle.
Rule: Do not touch the ball after it is released.

Rank the balls according to whether they are easier or more difficult to keep away from the goal. Put a name and description on each of four balls.

	Name for Ball	Description of Ball
Easiest to turn		
2nd easiest to turn		
3rd easiest to turn		
Most difficult to turn		

Think about the easiest ball to turn. What is it about this ball that made it easy to turn?

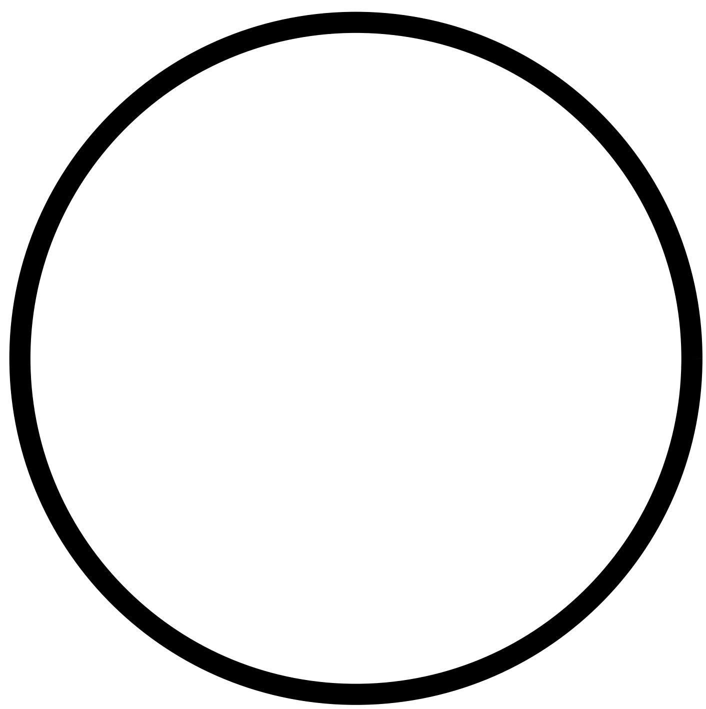
....

....

Think about the most difficult ball to turn. What is it about this ball that made it difficult to turn?

....

Lesson 4.1.5 Task Set Up



Lesson 4.1.5 Task Set Up

X release position

4.1 Force

These assessment items are intended to provide closure for each lesson and help teachers determine how well the students understand the science concepts. The assessments are also intended to provide students additional practice with the lesson content. Teachers should use the assessment items as they deem appropriate. For example, teachers may wish to assign them for homework, assign them as an additional class activity or "quiz" at the end of a lesson, or ask students to answer them individually as they leave the class (as "exit passes"). Teachers may wish to use the problems as a closing class activity, asking students to solve the problem in groups and then share their answers in a whole group closing activity.

The following sheets can be printed out for the students.

Application Problems 4.1.1 ***Exploring Position and Motion*** Name ....

Date ....

Which of the following is true about how all objects move?

e) Objects need a force to push or pull them before they can start or stop moving
f)Objects cannot move in a straight line, when pushed by a force
g) Objects can be moved up a steep slope with very little force
h) It takes more force to keep objects moving than to start them moving

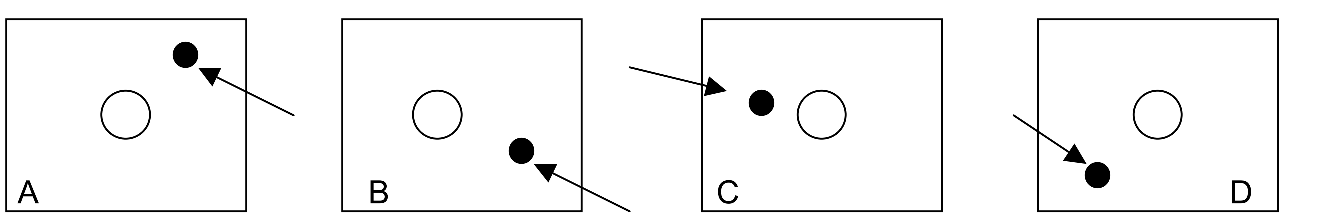
A child is cycling on flat ground and then cycles up a hill. Part way up she stops to talk to a friend and then starts riding up the hill again. Which of these requires the most force and which requires the least? Explain why you think so.

flat, level ground
continuing up hill
starting up hill from a stop

You are studying in the library on a warm day. The librarian turns the fan on the high speed and the pages of your report fly quickly across the room. Which of the following could happen if the librarian turns the fan on the lowest speed?

e) There would be no difference; the papers would blow just as quickly across the room.
f) The papers would blow into the fan
g) The papers would blow slowly away from the fan
h) Other objects such as paper clips and cups would fly across the room

The black dot represents a ball that is not moving. Which of the diagrams shows the correct way to blow to move the ball to make it start moving towards the central circle? Mark all correct choices.



Application Problems

Lesson 4.1.2

Exploring What Magnets Can Do

1. A science class magnet can pick up a paperclip. Explain why a refrigerator magnet can not pick up a refrigerator.

2. Label each of the following "True" or "False." Explain why you think so.

True	False	A magnet can pull on a paper clip.
True	False	A paperclip can pull on a magnet.
True	False	A magnet can push on a paper clip.
True	False	A paperclip can push on a magnet.
True	False	A magnet can pull on a magnet.
True	False	A magnet can push on a magnet.

2. Which is true about a magnet?
   a) A magnet is a force
   b) A magnet is an object
   c) A magnet can move another magnet without touching it
   d) A magnet can move the hands of a compass
   e) b, c and d
   f) all of the above

Application Problems

Lesson 4.1.3

Slow Down!

1. Mary and her friends are trying to move heavy furniture from the living room into the family room. The living room is carpeted and the family room has a tile floor. In which room will it be easier to slide the furniture? Explain why you think so. Use at least one scientific term in your explanation.

2. If you are riding your bicycle on flat level ground and stop peddling, which of the following is true?
   g) You keep going at the same speed because there is no force to slow you down
   h) You keep going at the same speed because the bike has a natural speed on flat ground
   i) You speed up because you had been pedaling before
   j) You speed up because you want to speed up
   k) You slow down because everything always slows down
   l) You slow down because friction is a force slowing your bike

Application Problems
Lesson 4.1. 4 Speeding Up with More Force and Less Mass

1. You and your best friend are helping with the grocery shopping. You have filled two shopping carts. Cart A is filled to the top with milk, orange juice and cans of vegetables. Cart B is filled with cereal boxes, an inflated beach ball and some bags of chips. The two carts are sitting next to each other when you and your friend decide to race the carts to the end of an isle. Which cart do you choose so that you can move more quickly? Explain how the carts are different even though they are filled to the same level.

2.You close your eyes and are given two closed containers of the same size. One container is full of un-popped pop corn kernels and the other is full of popped popcorn. Explain how you can tell which is ready to eat?

3. The diagram below shows three different objects: a brick, a block of wood, and an empty cardboard box. All three objects are pushed with the same amount of force at the same time.

Which object will reach the finish line first?

e) the brick
f) the block of wood
g) the empty box
h) they will all reach the finish line at the same time

4. Explain why a small mouse can jump quickly away from a big elephant even when the elephant is so strong that it can pull over a big tree.

Application Problems

Lesson 4.1.5

Which of the following is most likely to blow away on a windy day?

e) a picnic table
f) a lawn chair
g) a beach ball
h) a barbecue grill

Imagine you are pushing a shopping cart around a grocery store. Compare how it would feel to turn a corner pushing a cart that is full of milk and heavy cans, as opposed to an empty cart.

Heavy Cart	Empty Cart