Forces

Physical Science/Grade 3

Students will learn about how forces affect the world around them. They will also learn about the laws of physics, how forces can be balanced, and about invisible forces.

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This unit was developed with Race to the Top and National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised annually as the unit is piloted through the 2017-18 school year.

UNIT PLAN

Stage 1 Desired Results

- 3-PS2-1. Provide evidence to explain the effect of multiple forces, including friction, on an object. Include balanced forces that do not change the motion of the object and unbalanced forces that do change the motion of the object. **Clarification Statements:** Descriptions of force magnitude should be qualitative and relative. Force due to gravity is appropriate but only as a force that pulls objects down. **State Assessment Boundaries**: Quantitative force magnitude is not expected in state assessment. State assessment will be limited to one variable at a time: number, size, or direction of forces.

- **3.3-5-ETS1-1.** Define a simple design problem that reflects a need or a want. Include criteria for success and constraints on materials, time, or cost that a potential solution must meet. *

- **3.3-5-ETS1-2**. Generate several possible solutions to a given design problem. Compare each solution based on how well each is likely to meet the criteria and constraints of the design problem. **Clarification Statement:** Examples of

Meaning

UNDERSTANDINGS U

Students will understand that…

- Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative addition of forces are used at this level.)

- The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it.

- Objects in contact exert forces on each other. Electric and magnetic forces between objects do not require that the objects be in contact. The size of the force in each situation depend on the properties of the objects and their distances apart.

ESSENTIAL QUESTIONS Q

How do forces affect the world around us?

design problems can include adapting a switch on a toy for children who have a motor coordination disability, designing a way to clear or collect debris or trash from a storm drain, or creating safe moveable playground equipment for a new recess game. • **3.3-5-ETS1-4(MA).** Gather information using various informational resources on possible solutions to a design problem. Present different representations of a design solution. **Clarification Statements**: Examples of informational resources can include books, videos, and websites. Examples of representations can include graphic organizers, sketches, models, and prototypes. • **2006- PS- 9** Recognize that magnets have poles that repel and attract each other. • **2006- PS-10** Identify and classify objects and materials that a magnet will attract and objects and materials that a magnet will not attract.	***Student Learning Targets*** ***Students will be able to*** • Indicate whether or not an object will move • Generate a solution for a problem • Answer questions to demonstrate understanding • Predict the direction an object will move if given the strength and direction of the forces on an object • Predict whether or not an object will stop due to friction • Demonstrate that the higher an object is placed on a ramp the faster it will be once it comes off the ramp

Stage 2 - Evidence

Evaluative Criteria	Assessment Evidence
Pre-unit Assessment (if any)	End of year science test **Show What You Know!** Many lessons contain MCAS style multiple choice and open response questions to assess student understanding of the concepts presented in the lesson. The classroom teacher should administer the questions sometime after the completion of the lesson. The results can be used to plan additional lessons on concepts that students need help mastering.

Stage 3 – Learning Plan

PreK-PS2-1(MA). Using evidence, discussing ideas about what makes something move the way it does and how some movements can be controlled.

PreK-PS2-2(MA). Develop awareness of the factors that influence whether things stand or fall. Clarification Statement: Examples of factors in children's construction play include using a broad foundation when building, considering the strength of materials, and using balanced weight distribution in a block building.

K-PS2-1. Compare the impacts of different strengths and directions of pushes and pulls on the motion of an object. Clarification Statements: Examples of pushes or pulls could include a string attached to an object being pulled, a person pushing an object, a person stopping a rolling ball, and two objects colliding and pushing on each other. Non-contact pushes or pulls such as those produced by magnets are not expected.

Lesson Overview

Lesson 1 - Students will investigate that objects at rest stay at rest unless acted upon by an outside force. Students will watch a video regarding forces and motion and brainstorm different ways to move an object. Then the students will learn (through examples) that in order to affect the speed of an object, you must apply force to that object. Students will practice their engineering and design skills as they test their airplanes, research flight, modify their designs, and test them again.

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Lesson 2 - Students will learn about balance. Students will also observe various demonstrations showing them how forces act on an object. Students will also participate in an activity using ping pong balls and straws where they will learn about how forces interact. Students will then make mobiles to further their understanding of balance. **Lesson 3** - Students will learn about friction through a guided discussion. Then they will experiment with different materials to see how much friction they can produce. Then the students will learn about gravity through a guided discussion. The students will also learn about air pressure and how it keeps planes afloat.
Adapted from Massachusetts Department of Elementary and Secondary Education's Model Curriculum Unit Template. Originally based on Understanding by Design 2.0 © 2011 Grant Wiggins and Jay McTighe. Used with Permission July 2012

Tiered Vocabulary List

Tier 1	Tier 2	Tier 3
Push Pull	Force Trail Research Speed Diagram Balance Experiment Laws of physics	Scale Newton Friction Gravity Air pressure

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Lessons At-A-Glance

Lesson Number	Core Activities	Extensions	Tech Integration	Field Work
1	• Do objects move on their own? • Force Discussion • Think-Pair-Share • Airplane Activity		Bill Nye Video YouTube	Airplane
2	• Rope Pulling • Force Diagram • Ping Pong Ball activity • Mobile Making			Rope Pulling
3	• Friction Discussion • Friction Investigation • Gravity Discussion • Ramp Lab • Airplane Explanation	Full Bill Nye Video	Bill Nye Video YouTube	

Lesson 1: Investigating Forces and Motion

BACKGROUND

Overview of the Lesson

Students will investigate that objects at rest stay at rest unless acted upon by an outside force. Students will watch a video regarding forces and motion and brainstorm different ways to move an object. Then the students will learn (through examples) that in order to affect the speed of an object, you must apply force to that object. Students will practice their engineering and design skills as they test their airplanes, research flight, modify their designs, and test them again.

Focus Standard(s)

3-PS2-1. Provide evidence to explain the effect of multiple forces, including friction, on an object. Include balanced forces that do not change the motion of the object and unbalanced forces that do change the motion of the object. [**Clarification Statements:** Descriptions of force magnitude should be qualitative and relative. Force due to gravity is appropriate but only as a force that pulls objects down. **State Assessment Boundaries**: Quantitative force magnitude is not expected in state assessment. State assessment will be limited to one variable at a time: number, size, or direction of forces.]

3.3-5-ETS1-2. Generate several possible solutions to a given design problem. Compare each solution based on how well each is likely to meet the criteria and constraints of the design problem. [**Clarification Statement:** Examples of design problems can include adapting a switch on a toy for children who have a motor coordination disability, designing a way to clear or collect debris or trash from a storm drain, or creating safe moveable playground equipment for a new recess game.]

3. R. 1. Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.

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Learning Targets

I can indicate whether or not an object will move.
I can generate a solution to a problem.
I can answer questions to demonstrate understanding.

Assessment

Students will be assessed on their participation in discussions. A worksheet will assess their knowledge of the core concepts taught.

WIDA Language Objectives

(Dependent on the needs of your ELL students)

Key Vocabulary

Tier 1: push, pull
Tier 2: force, trial, research, speed

RESOURCES AND MATERIALS

Quantity	Item	Source
1 per student	White paper	Classroom Teacher
1 per group	Ipads	Classroom Teacher
	Bill Nye "Force and Motion"	Thumb drive
1 per student	Isaac Newton Reading and Questions	Binder
1 roll	**Masking Tape**	**Bin**

****Items in bold should be returned for use next year****

LESSON DETAILS

Lesson Opening/ Activator

1. **Teachers should make a paper airplane before the lesson begins- this will be used for demonstration purposes**. Ask the students if any of them have ever flown in an airplane. Allow the students to share their experiences. Throw the paper airplane across them room, ask the students to share what they observed. How long did the plane stay afloat? Why did it fall to the ground? What would happen if we threw this plane outside- would there be factors that would impact the planes movement? Tell the students that at the end of this lesson they will be airplane engineers and will design their own airplane.

During the Lesson

1. **Do Objects Move on Their Own?**
   a. The teacher or science fellow should pretend to be an inanimate object. Ask for a volunteer to come lightly push on the person who is acting as an inanimate object. Ask the students to share what the observed. When did movement happen? Could the object move on its own?

   b. Now have the class choose an object, *the* "Object" can be anything. Let's say the class selected a chair. Ask the students to encourage the "object" to move, have them say things like "*Please move over here! I have a cake!"* Ask the class for ideas on what they can say to the "object" to get them to move.

   c. After some failed attempts, ask the class "*Is there anything else we can do to move the chair?"* Lead the discussion to the conclusion that someone will need to push or pull the "object" to get them to move. Tell the students to remember that an object at rest will stay at rest unless an outside force pushes/pulls the object.

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2. **Force Discussion [SP6 - Constructing Explanations]**
   a. Now, ask the students if they know anything about forces. Allow the students to share their prior knowledge. Now show the students the Bill Nye video "Force and Motion". Before the video, tell the students to listen for what happens to an object at rest, and an object in motion. Once the video is over, go over the concepts with the students. Ask them "*Do objects at rest ever move on their own? Did the boxes move on the truck by themselves?*" "*Do objects in motion ever stop on their own? What would happen if an object in motion had no forces affecting it?*"

   b. Write the following two sentences on the board "*Objects in motion stay in motion unless acted upon by an outside force.*" *"Objects at rest stay at rest unless acted upon by an outside force***."** Tell the students that these are two laws of physics that they will be learning about during this unit. These laws were written by Sir Isaac Newton.

3. **Think-Pair-Share**: **[SP 8 - Obtaining, evaluating, and communicating information]** Tell the students that they will brainstorm different ways to apply a force to an object. Now put the students in pairs and ask them to think of examples of how they could apply a force to an object, either directly or indirectly. Give the students 5-10 minutes to brainstorm and then have some of the pairs share their examples. Lead the conversation to the conclusion that every way of moving an object is either a:
   1. Push
   2. Pull
   3. Collision
   4. Friction

   Note: Again, friction will be covered in lesson 3, but it can be mentioned if the students bring it up themselves.

1. Tell the students that when you put a force on an object, you affect that object's speed. Ask the students if they have ever seen someone skateboard. Allow a student to share with the class what skateboarding is. Ask the students "*What happens*

when someone pushes on the ground while on a skateboard?" Lead the discussion to the conclusion that when someone skateboards, they push the ground to gain speed with the skateboard. Tell the students, "*Each push has the same amount of strength behind it, but the skateboard keeps going faster and faster because the speed increases with every push."*

5. **Airplane Activity:** (This part of the lesson was adapted from: [http://betterlesson.com/lesson/641889/flying-into-a-problem-1-3]
    a. Put the students into groups of 2-4. Tell the students that they are going to use what they know about forces to become airplane engineers. Ask the students if they think they will be able to make a paper airplane that can fly at least 5 feet.

    b. Give each group a few sheets of paper. Have the students discuss their airplane designs with their group. Once they have agreed on a design, they will make their airplane. **Note: The students should not use paper clips in their designs.**

    c. *Initial Testing:* Once every group has made their airplane, each group will take turns testing their airplane down a long hallway or across the classroom. Make sure that all students are behind the student throwing the airplane. Each group will test their airplane 3 times. Tell the students to make three columns in their science journal. One column for each trial. For each column, the students should write down the heading "Trial" followed by the corresponding number. Tell the students to jot down any observations from their test flights in the column for that trial. Once a student's paper airplane hits the ground, put a piece of masking tape on the ground where the plane landed. Write down the names of the students on the piece of masking tape followed by the trial number. Tell the students that they should not make any changes to their designs during the testing.

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d. *Research and Revision:* Tell the students that they are now going to fix/change their designs. Tell the students that engineers often research their topics to understand how to design them better. Give each group an ipad (or more if the supply allows for it) and write the following websites on the board.
   i. http://www.funpaperairplanes.com/learn_about_flight.html
   ii. http://www.scholastic.com/teachers/article/what-makes-paper-airplanes-fly
   iii. http://www.sciencebuddies.org/science-fair-projects/project_ideas/Aero_p046.shtml#background
   iv. http://www.bestpaperairplanes.com/

   Tell the students that they should use the links to research how they can fix any issues with their designs.

e. Walk around the room and ask the students what they are thinking about their designs. Encourage them to try out new things, taking ideas from the resources and to not simply copy a design from the internet. Allow the students around 10-20 minutes to research and design. **Note: Allow the students to struggle with their design problems. This is meant to get them thinking like an engineer.**

f. Gather all the students once again to test their designs. Have each group test their designs. Again, have them write down any observations in the science journal under a heading titled Trial 2. Make sure that all students are behind the student throwing the paper airplane to avoid any injuries. Have each group test their design 3 times.

6. Ask the students to share what they have learned about the mechanics of flight. Ask the students if anyone can explain how a paper airplane is able to fly. Ask them what sorts of forces are involved in flight. *"Are there any pushes? Any pulls? Any collisions?"* Finally ask the students if they were able to use what they learned to improve their designs.

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Assessment

Students will be assessed on their participation in class discussions and activities.

Literacy Extension: To be taught by the teacher, this activity should be planned by the classroom teacher and completed before lesson 3. "Famous Scientists – Sir Isaac Newton" and questions

Lesson 2: Balanced and Unbalanced Forces

BACKGROUND

Overview of the Lesson

Students will learn about balance. Students will also observe various demonstrations showing them how forces act on an object. Students will also participate in an activity using ping pong balls and straws where they will learn about how forces interact. Students will then make mobiles to further their understanding of balance.

Focus Standard

3-PS2-1. Provide evidence to explain the effect of multiple forces, including friction, on an object. Include balanced forces that do not change the motion of the object and unbalanced forces that do change the motion of the object. [**Clarification Statements:** Descriptions of force magnitude should be qualitative and relative. Force due to gravity is appropriate but only as a force that pulls objects down. **State Assessment Boundaries**: Quantitative force magnitude is not expected in state assessment. State assessment will be limited to one variable at a time: number, size, or direction of forces.]

Learning Target

I can predict the direction an object will move if given the strength and direction of the force on an object.

Assessment

Students will be assessed on their participation in class discussions and on the exit ticket.

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WIDA Language Objectives

[Dependent on the needs of your ELL students]

Key Vocabulary

Tier 2: diagram, balance

Tier 3: scale, Newton

RESOURCES AND MATERIALS

Quantity	Item	Source
1	**Rope**	**Bin**
1	**Balance Scale**	**Bin**
15	**Marbles**	**Bin**
1	**Ball with strings attached**	**Bin**
3 boxes	Straw	Bin
15	**Ping pong balls**	**Bin**
1 per student pair	Ping Pong ball handout	Binder
2 packets	**Index Cards**	**Bin**
	Paper clips	Classroom Teacher
1 per student	Ruler	Classroom Teacher
	Mobile Poster	Binder
	Craft supplies for decorating mobiles	**Bin**

****Items in bold should be returned for use next year****

LESSON DETAILS

Lesson Opening/ Activator

Ask the students about what they learned in the last lesson. Allow them to share. In order to help them remember, remind them about the activity where the "object" refused to move until someone pushed/pulled them. Write the two laws of physics on the board. Tell the students that they will continue to use them to learn more about forces.

- An object at rest stays at rest unless affected by a force
- An object in motion stays in motion unless affected by a force

The teacher or science fellow will need the balance scale and marbles for the initial demonstration. Tell the students that right now the scale is balanced, both sides of the scale are in the middle. Now put 5 marbles onto one side. Show the students that the scale is now unbalanced, one side is lower than the other. Ask the students "*Does anyone know how we can balance the scale again without removing any marbles?"* The students need to find the correct number of marbles to place on the empty side of the scale that will result in the scale being balanced. Ask the students "*How many marbles did it take to balance the scale?"* and "*How does that number compare the number of marbles on the other side of the scale?"* Lead the discussion to the conclusion that the scale was balanced when both sides had the same number of marbles pushing down. Ask the students "*Does it have to be the same amount on each side for it to be balanced? What if I take one off this side?"* Remove one marble from a side. Lead the discussion that there needs to be an equal amount on each side in order for the scale to be balanced. Leave the scale at the front of the room to reference during the lesson.

During the Lesson

1. Ask the students "*Are you all at rest right now? Are you not moving?"* They should all say yes to this. "*So are there any forces affecting you right now?" Allow the students to share any answers. Actually, there are forces pulling on you at all times!"* Point out gravity, a constant force pulling us towards the ground. Then ask the students "*So if gravity is pulling you down, why do*

you think you're not moving?" Allow the students to try to answer this with their own theories. The correct answer is that the chair they are sitting on is actually pushing them upwards. Lead the discussion to this conclusion. Ask the students "*So if there's a force pulling you down, and a force pushing you up, why are you still? Why aren't moving all over the place?"* Allow the students to answer. Lead the discussion to the conclusion that the force pushing you up and the force pulling you down cancel each other out. Tell the students that the forces are balanced, just like the scale. Tell the students that when the forces on an object are balanced, that object is at rest.

a. **Rope pulling: (This part of the lesson can and should be done outside if possible)** Ask the students if they have ever played the game "Tug of War". If they have, ask for a volunteer that can explain how the game is played. If no students can explain the rules, then the teacher or science fellow should explain them.

b. Ask for three volunteers. Tell the students that they are going to be forces acting on an object. Try to pick students who have similar strengths. Take out the rope and tell the students that two of the volunteers will be on one side of the rope and the third will be on the other side of the rope. Tell the students that the unit of measurement scientists use to measure forces are **Newtons,** named after Isaac Newton. Tell the class that each volunteer is one newton. Ask the students how many newtons are on the side with two students (two newtons). Ask the students how many newtons are on the side with one student (one newton).

c. Have these students play tug of war. Ask the students "*Imagine that there's a ball glued to the middle of the rope, which direction will the ball move? Why?"* Allow the students to answer. Lead the discussion to the conclusion that the ball moved towards the side with more people since they had more newtons of force.

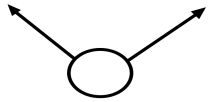
d. Now ask for two more volunteers. Add these students to the side of the rope with only one student. Ask the students "*What will happen this time? Which side will potentially win? Why?"* Allow the students to answer. Have the students

play tug of war again. Now finally ask for one last volunteer. Add this student to the side with two students. Each side should have three students now. Ask the class "*What will happen this time?*" Allow the students to answer. Lead the discussion to the conclusion that it will be a closer game because each side has an equal amount of people, or newtons. The sides are balanced.

3. **Force Diagram**: Draw a circle on the board. Draw two arrows out from the circle (which represents a ball), these arrows should form a right angle (see image below). Tell the students that this is a force diagram, a helpful tool scientists use to visualize how forces affect an object. Tell the students "*Imagine there are two strings where the arrows are. Now imagine that we pull on both the strings at the same time. How will the ball move?*" Allow the students to share their predictions.

4. Now take out the ball which has two strings attached to it. Hold it in the same way as depicted in the image below.

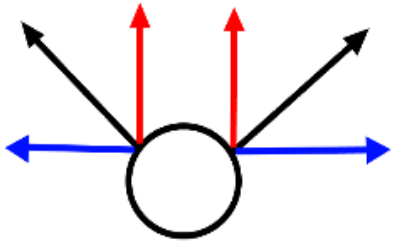
   a. Ask the students to make predictions of what will happen when you pull the strings. Pull on each string separately. That is, pull one string, then pull the other string.



   b. Now pull on both the strings at the same time. The ball should move straight up. If any of the students predicted this correctly, ask them if they can explain what happened. Allow the students to share their theories and explain what they observed.

c. Explain to the students that the string on the left pulled the ball up and to the left, the string on the right pulled the ball up and to the right. Since one string pulled to the left and the other pulled to the right, those two parts of the force were balanced and canceled each other out, similar to the tug of war. The only remaining part to the forces was an upwards force from both strings, so the ball moved upwards. **Note: this concept takes some time to fully understand. If the students ask for better explanation, refer to description below to help solidify the concept.**

Figure 2



Every force has a x component, indicated by the blue arrows and a y component, indicated by the red arrows

The x components, the blue arrows, are balanced. This means the object will not move left to right.

The y components however are not balanced. They are both pulling the object upwards.

Since the object is balanced in the x components but not in the y components, the object will move upwards.

4. **Ping pong ball activity: [SP 3 - Planning and Carrying out investigations]** Partner up the students and give each pair a ping-pong ball, two straws, and the ping pong ball handout. The handout has a circle labeled **start**. This is where the students should initially place the ping pong ball. Next to each **start** circle, there are two arrows pointing towards the circle. This is where the students are allowed to blow on the ball with their straws. The handout also has 3 circles labeled **end.** This is where the students are trying to roll the ball towards. The **ends** are numbered 1, 2, and 3.

a. Each group will need to get the ball to roll over the first end circle (labeled with a 1) only by blowing on the ball along the arrows. Have the students discuss in their groups what their plan is before going ahead and blowing on the ball.

b. Walk around and help the students when necessary. Ask the students "*Do you think you need both the straws to blow at the same time?* Once a group has succeeded in getting the ball to roll over the end circle, tell them to try to get the ball to roll over the next end circle.

***** If time is a concern, the lesson can be broken up here*****

5. **Mobile Making: [SP 2 - Developing and using models]** Tell the students that they will be making mobiles. The students may take these home. Give the students paperclips, index cards, straws, rulers, and any other craft materials you may have in the classroom. Go over the following steps with the students.

   a. Tape a ruler off the edge of the desk so that half the ruler hangs over the edge of the desk.

   b. Unbend a paperclip so that it has a hook on either end. The top hook will hook onto the ruler. The bottom hook will hook onto the middle of a straw.

   c. The students will then make their mobiles by adding index cards or other craft materials to either side of the straw, keeping everything in balance while doing so. Students can also add more straws to the ends of straws to make a larger mobile. Students can add objects to the ends of straws by making another paper clip hook. These can be used to then attach the objects to the straws.

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d. As the students are making their mobiles, walk around and help them balance their mobiles if necessary

Note: Refer to the Mobile Poster in the binder to see example mobiles. In the examples, rubber bands are used with the paper clips to hold objects. You may do this as well if you have rubber bands.

Lesson Closing

Ask the students what happened when their mobiles were unbalanced. Lead the discussion to the conclusion that when their mobiles were unbalanced, the mobile would fall towards the heavier side. Compare this to the game of tug of war that force play on an object. When one side has more force, the object will move with that force. Now tell the students that when their mobiles were balanced, the mobile would not move. Ask the students if they have any questions regarding what they learned today.

Assessment

Students will be assessed on their participation in class discussions.

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Lesson 3: Unseen Forces

BACKGROUND

Overview of the Lesson

Students will learn about friction through a guided discussion. Then they will experiment with different materials to see how much friction they can produce. Then the students will learn about gravity through a guided discussion. The students will also learn about air pressure and how it keeps planes afloat.

Focus Standard

3-PS2-1. Provide evidence to explain the effect of multiple forces, including friction, on an object. Include balanced forces that do not change the motion of the object and unbalanced forces that do change the motion of the object. [**Clarification Statements:** Descriptions of force magnitude should be qualitative and relative. Force due to gravity is appropriate but only as a force that pulls objects down. **State Assessment Boundaries**: Quantitative force magnitude is not expected in state assessment. State assessment will be limited to one variable at a time: number, size, or direction of forces.]

Learning Targets

I can predict whether or not an object will stop due to friction.
I can demonstrate that the higher an object is placed on a ramp the faster it will be once it comes off the ramp.

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Assessment

Students will be assessed on their participation in class discussion.

WIDA Language Objectives

[Dependent on the needs of your ELL students]

Key Vocabulary

Tier 2: Experiment, laws of physics

Tier 3: Friction, gravity, air pressure

RESOURCES AND MATERIALS

Quantity	Item	Source
1 per group	**Wooden ramp**	**Bin**
1 per group	**Small ball**	**Bin**
1 per group	**Milk Carton (or similar hollow box)**	**Bin**
1 per group	Ruler	Classroom Teacher
1 per group	**Block of wood**	**Bin**
1 per group	**Square of carpet**	**Bin**
1 per group	**Square of Sandpaper**	**Bin**
1 per group	**Square of Felt**	**Bin**
1 per group	**Square of Laminated paper**	**Bin**
	Bill Nye Flight Video	Thumb drive

1 per student	Ramp Lab Worksheet	Binder

****Items in bold should be returned for use next year****

LESSON DETAILS

Lesson Opening/ Activator

Tell the students that up until now, they've been learning about the forces they can see. Ask for examples of forces that they've seen in the past few lessons. Some examples may include pushing, or pulling on objects, and collisions. Once the students have shared some forces, tell the that there are also invisible forces everywhere. Ask the students "*If we can't see these forces, how can we tell if they're there?*" Lead this discussion to the conclusion that we can look at how objects move.

Write the following on the board at the front of the room "*1. An object in motion will stay in motion unless acted upon by an outside force"* and "*2. An object at rest will stay at rest unless acted upon by an outside force"* Tell the students that these are two laws of physics that they are going to use to find the invisible forces.

During the Lesson

1. Ask the students to describe what happens when you roll a ball. When the students state the fact that the ball will eventually stop moving, say "*That's strange, doesn't law number 1 say that an object will stay in motion unless acted upon by an outside force? What's happening there?"* Allow the students to share any ideas they may have. Tell the students "*There must be an unseen force stopping the ball from moving! Lets think about this with another example. Has anyone ever seen a game of hockey? In hockey, players push a small puck, a flat circle, over ice and try to make goals. Does anyone know why they play on ice? What would happen if you pushed the hockey puck over pavement?"* Lead the discussion to the conclusion that hockey is played on ice because ice is "slippery" (or something similar to that). Tell the students that sometimes when you try pushing

an object over a surface, that surface doesn't want the object to move, so it resists the motion of the object. This resistance is called friction. Some materials, like ice, have less friction than others. Tell the students that friction is an unseen force that pushes on an object opposite the direction it is moving in. Draw Figure 1 on the board to help explain this concept.

Figure 1

The car is moving towards the right
Friction is pushing the car to the left

If the car is turned off, there is no force pushing it to the right. That means that the car will start to slow down due to the force of friction pushing it to the left.

2. **Friction investigation: [SP 3 – Planning and Carrying out investigations]**
    a. Divide the students into groups of four. Tell the students that they are going to be explore how much friction different materials can produce. Give each group a block of wood, a square of carpet, a square of sandpaper, a square of felt, and a square of laminated paper.

b. Tell the students to predict in their science journals which material they think will produce the least amount of *friction*. Tell the students to draw four columns in their science journals. Put the following labels on the columns:
    i. Carpet
    ii. Sandpaper
    iii. Felt
    iv. Laminated paper

c. Now tell the students to slide the block of wood across each of the materials, writing down observations in their science journals. For each material, tell the students to use words such as "Fast, slow, Rough, Smooth, Slippery" in their observations on how the materials impact the speed of the block of wood as it is being pushed across.

d. The students should give the block of wood a push and then they will see how much resistance the block encounters. If necessary, provide a demonstration of a proper push prior to the students beginning the activity.

e. Tell the students to number the different materials in terms of how much friction they produced. Number 1 will be the material with the least friction and 4 should be the material with the most friction. This should be written down in their science journals. Ask each group to share their results. Which material produced the least friction? Which material produced the most friction?

3. **Ramp Lab: [SP 3 – Planning and Carrying out investigations]**
    a. Now have each group clean up their materials from the last activity and then give them a ramp, a milk carton, a ruler, a ball, and the ramp lab worksheet. Go over the following instructions with the groups. Each group will put the milk carton at the base of the ramp. They will then put the ball at three positions on the ramp, at the top, in the middle, and at the base. They will release the ball and it will roll down the ramp and hit the milk carton. They will

then measure how far the milk carton goes using the ruler. They will write down the distance onto the worksheet using centimeters.

b. However, before the students start the lab, tell the students to write down their hypothesis, a scientific guess. Tell the students to predict which position of the ball will make the milk carton go the furthest. They will write down these predictions on the ramp lab worksheet.

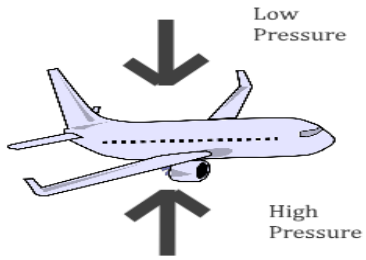
c. Once all the students have completed the labs, bring the class together for a discussion. Discuss the lab results, and ask the students if their predictions were correct. Ask the students "*Why was the top of the ramp the best position for the ball?"* Lead the discussion to the conclusion that the longer the ball was able to roll, the faster it went.

Lesson Closing

Drop a piece of paper onto the ground. Tell the students to watch as it floats downwards. Ask the students "*Why the paper does not just fall straight to the ground, why does it float a little?*" Lead the discussion to the conclusion that there is air which hits the paper in a certain way. Tell the students that there is air all around them that is constantly pushing on them from every direction. Tell them this is another invisible force called air pressure.

This unit was developed with Race to the Top and National Science Foundation funding (Grant #1432591). It is a DRAFT document that will be revised annually as the unit is piloted through the 2017-18 school year.

Figure 3



Now tell the students that plane wings are a special shape. This shape makes the air moving above the wing move really fast, and the air moving below the wing move really slow. This causes the air pressure above the wing to be much less than the air pressure below the wing. This is a complicated concept, it may be helpful to show them the Bill Nye video "Forces of Flight" (https://vimeo.com/83625163) from 9:30 to 11:55. Now draw figure three on the board. Tell the students that there is low pressure pushing down on the airplane up top, and high pressure pushing up on the airplane from the bottom. Since the force pushing upwards is greater than the force pushing downwards, the airplane moves in the direction of the larger force, so upwards.

Optional Extension:

If the students are interested in learning more about flight, show them the Bill Nye "Forces of Flight" video (~23 minutes) [https://vimeo.com/83625163]. Screen the video to find a section specific to their interests.

Assessment

Students will be assessed on their participation in class discussion.

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List of Unit Resources

Lesson 1

Quantity	Item	Source
1 per student	White paper	Classroom Teacher
1 per group	Ipads	Classroom Teacher
	Bill Nye "Force and Motion"	Thumb drive
1 per student	Isaac Newton Reading and Questions	Binder
1 roll	**Masking Tape**	**Bin**

Lesson 2

Quantity	Item	Source
1	**Rope**	**Bin**
1	**Balance Scale**	**Bin**
15	**Marbles**	**Bin**
1	**Ball with strings attached**	**Bin**
3 boxes	Straw	Bin
15	**Ping pong balls**	**Bin**
1 per student pair	Ping Pong ball handout	Binder
2 packets	**Index Cards**	**Bin**
	Paper clips	Classroom Teacher
1 per student	Ruler	Classroom Teacher

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	Mobile Poster	Binder
	Craft supplies for decorating mobiles	**Bin**

Lesson 3

Quantity	Item	Source
1 per group	**Wooden ramp**	**Bin**
1 per group	**Small ball**	**Bin**
1 per group	**Milk Carton (or similar hollow box)**	**Bin**
1 per group	Ruler	Classroom Teacher
1 per group	**Block of wood**	**Bin**
1 per group	**Square of carpet**	**Bin**
1 per group	**Square of Sandpaper**	**Bin**
1 per group	**Square of Felt**	**Bin**
1 per group	**Square of Laminated paper**	**Bin**
	Bill Nye Flight Video	Thumb drive
1 per student	Ramp Lab Worksheet	Binder