# Balanced and Unbalanced Forces

3.4

Image via iStock.com/Wavebreakmedia

## Anchoring Phenomenon

Objects move in different ways during physical activities on the playground.

## Lesson Concept

Plan and conduct an investigation of the effects of balanced and unbalanced forces in a tug-of-war.

## Investigative Phenomenon

Small children on the playground win a tug-of-war challenge against a group of bigger children.

## Standards

Refer to Appendix 3.4 for NGSS, CCSS—ELA, and California ELD standards.



A project of CA NGSS K–8 Early Implementation Initiative.

## Storyline Link

In Lesson 3: Patterns in Motion, students continued to build on their fundamental understandings of force and motion with a soccer ball. They analyzed and interpreted data about how the strength of an unbalanced force impacts the distance the object moves.

In this lesson, the students work with a non-ball example (tug-of-war) to continue to explore the cause and effect of balanced and unbalanced forces on an object in addition to the effects of the strength and direction of the force. They apply that understanding to the design of the playground. In the next lesson, students apply their learning from the basketball, soccer, and tug-of-war games to design a new activity for the redesigned playground.

Throughout the unit, a flag (▶) denotes formative assessment opportunities where you may change instruction in response to students' level of understanding and making sense of phenomena or solving a problem.

## Time

### 6 hours and 15 minutes (5–6 days to complete)

| | | |
|---|---|---|
| Part I | 40 minutes | Engage |
| Part IIa | 45 minutes | Explore 1 |
| Part IIb | 60 minutes | Explore 2/Explain 1 |
| Part IIc | 20 minutes | Explore 3/Explain 2 |
| Part IId | 60 minutes | Explore 4/Explain 3 |
| Part III | 60 minutes | Explain 4 |
| Part IV | 90 minutes | Elaborate/Evaluate |

## Materials

### Whole class

- ❑ Tug of War video (https://www.youtube.com/watch?v=gSZCZ0UuI10)
- ❑ Unbalanced Force video (https://study.com/academy/lesson/unbalanced-force-definition-example-quiz.html)
- ❑ 2 Ropes for tug-of-war
- ❑ Large whiteboards for each table group (markers and erasers) OR poster paper
- ❑ 3.1.C3: Tug-of-war (from Lesson 1: Movement on the Playground)
- ❑ 3.2.C1: Observable Features of Models (from Lesson 2: Forces Move Objects)
- ❑ 3.4.C1: Number of Students Class Data Table
- ❑ 3.4.C2: Strength Class Data Table
- ❑ 3.4.C3: New Game Direction Rules

Optional

- A Force is a Push or Pull video (https://goo.gl/3xQVVz)
- PHET Forces & Motion simulation (https://PhET.colorado.edu/en/simulation/legacy/forces-and-motion)

## Individual

- Science notebook
- Sticky notes
- 3.4.H1: Number of Students Data Table
- 3.4.H2: Strength Data Table

## Teacher

- TalkScience resource (http://stemteachingtools.org/assets/landscapes/TalkSciencePrintable.pdf)

# Advance Preparation

1. Prepare two sturdy ropes with a marker in the middle. Tie grip knots every 2 to 2.5 feet for controlled spacing and reduced slippage (which will cause rope burns).
2. Preview the Tug of War video (https://www.youtube.com/watch?v=gSZCZ0UuI10)
3. Preview the Unbalanced Force video (https://study.com/academy/lesson/unbalanced-force-definition-example-quiz.html) **STOP AT 1:15** (*after the forces in many directions acting on the barrel*). The rest of the video covers middle-school concepts.
4. Find **3.2.C1: Observable Features of Models** (from Lesson 2: Forces Move Objects). (It should be still up on the wall.)
5. Print out **3.4.C1: Number of Students Class Data Table**, **3.4.C2: Strength Class Data Table**, and **3.4.C3: New Game Direction Rules** to use with the document camera or make a chart.
6. Make copies of **3.4.H1: Number of Students Data Table** and **3.4.H2: Strength Data Table**.
7. Review TalkScience resource (http://stemteachingtools.org/assets/landscapes/TalkSciencePrintable.pdf) to determine when best to use this resource for student-to-student discourse.

## Procedure

### Part I

Engage (40 minutes)

*Relate information about forces and motion in balls to non-ball objects and observe the cause and effect of a tug-of-war.*

1. ▶ Pair students and ask them to review the big ideas they have learned about force and motion using a basketball and a soccer ball. Have several partners share. *ESRs: Objects have forces acting on them. If the forces are balanced, the object does what it was doing (if still, it remains still; if moving, remains moving). If the forces are unbalanced, it will cause a change in the ball's speed or direction. Forces have strength and direction; we can predict future motion by looking at patterns.*
2. Tell students, "We have talked about forces on balls. What other objects are on the playground are not balls, but involve motion? *ESRs: swings; slides; see-saws, monkey bars.*

> **TEACHER NOTE**
>
> In this lesson, the students work with a non-ball example (tug-of-war) to continue to explore the cause and effect of balanced and unbalanced forces on an object in addition to the strength and direction of the force. This reinforcement of the basic concepts of force and motion provides struggling students with additional opportunities to make sense of the experiences they had in the first two lessons. Tug-of-war is a physical demonstration of balanced and unbalanced forces.

3. Show the students the rope. Ask if any one has any ideas about how this object can be used to show motion. Take a couple of ideas, and if necessary, introduce the game of tug-of-war. Have students discuss in pairs how their ideas of force and motion might work in a tug-of-war. Ask a couple of partners to share their ideas.

   *Expected Student Responses (ESRs):*

   - *Big kids can pull the rope harder and win.*
   - *Little kids can't pull the rope as hard.*
   - *A team has to unbalance the force to move the marker across the line.*
   - *The number of kids on each side matters to make it balanced.*

4. Say, "Let's see if any of our ideas happen in a tug-of-war." Play the Tug of War video and stop it at 10 seconds. Ask students to predict what is happening on both sides. Have them write their ideas in their science notebook.
5. Continue to play the Tug of War video and stop at 36 seconds. Ask students to predict who/what is on the other side of the rope and write their ideas in their science notebook.

6. Continue to play the Tug of War video to the end. Ask students to write any questions they have about this phenomenon in their science notebook. Have them pick two that they want to share and write them on sticky notes.
7. Ask individuals to share one or two of their questions with their table group. Then have the table group select three or four questions that they want to share with the class.
8. Invite table groups to share their sticky notes (clump those that are similar) on the class whiteboard. Review the questions.

## Part IIa

### Explore 1 (45 minutes)

*Ask questions and plan an investigation to test the effect of the number of students on each side of a rope on the movement of the marker.*

9. Ask, "Which of these questions can we investigate to find out what might have caused this to happen? Do we have any testable questions on our list? Circle those that are appropriate. Call out the variables in those questions (e.g., *number of students on the rope, size of the students on the rope, boys versus girls on the rope, strength of pulling the rope*).
10. Ask, "What do we need to think about in order to conduct an investigation of these variables?"

**TEACHER NOTE**

If this is the first time your students are planning an investigation, guide them in a discussion of:

- What is the phenomenon we are trying to understand? (e.g., in this case, how did the kids in the video win)?
- What is the question we are trying to investigate? (e.g., does changing the number of students on each side of the rope affect the way the rope is pulled?)
- What is the variable we are testing? (e.g., in this case, the number of students)
- What will we observe? (e.g., in this case, does the side with most students win by pulling the marker over the line?)
- How many times to we need to test it? (in this case at least 3 times)
- How many variables can we test at a time? (only one)

11. Explain that data can be observation or measurements. Ask students what they think they could observe or measure. (e.g., observe: when the marker moves; how the students move; number of back-and-forth movements; measure: distance marker moved; count the number of participants on each side, who is stronger). Remind students that sometimes measurement requires certain tools, and we don't have the tools to measure strength. Therefore, our data can be observations and counting the number of students and the distance the marker moves.

12. After the students have identified the question, variable to test, and what they will observe, ask them to share ideas on how they can collect their data.
13. Use their ideas to collaboratively plan the steps for their investigation. Show them the material that they have (i.e., two tug-of-war ropes, each with a marker in the middle and **3.4.H1: Number of Students Data Table**).

TEACHER NOTE

If students have never developed a plan for an investigation, guide them in understanding that the plan is a set of steps they will do to gather data about their question. Their steps should be sequential, and others should be able to follow them.

Below is a suggested plan.

Example Plan:

Before we go outside:

1. Divide the class into two teams of equal size. (32 students = 2 groups of 16)
2. Further divide each team into two groups of equal size. (16 students = 2 groups of 8)
3. Label groups of 8 as team A, B, C, D.
4. Teams A and B will work together. Teams C and D will work together.
5. Since what we are testing is does the number of players make a difference, have one or two members from team A participate on team B for this test so you have uneven teams.
6. Teams A and C will tug-of-war. They get two turns.
7. Teams B will observe team A, and team D will observe team C. They will record their observations in a data table.

When we get outside

8. Give one rope to team A and show them their designated spot. Give the other rope to team C/D and show them their designated spot.
9. Distribute **3.4.H1: Number of Students Data Table** to the observing teams.
10. Have team A and C get into position.
11. Have team B and D get close enough to watch the tug-of-war without getting in the way.
12. Have the two teams pick up the rope. Remind students to not wrap the rope around their wrists!
13. Tell the teams to pull as hard as they can on the rope and that the winning team will be the one who can pull the first person of the other team across the line towards them.
14. Yell "start," and the teams begin the pull.
15. Yell "stop," and the teams drop the rope where they are.
16. Repeat the process with the same teams one more time. Make sure teams B and D complete **3.4.H1: Number of Students Data Table**.

TEACHER NOTE (continued)

17. Switch the roles of the teams: Team B and D now pull the rope, team A and C record observations. Then repeat with Teams A and D and Teams B and C.
18. Repeat the process with the new teams, making sure they have two trials.
19. Return to the classroom to discuss the data.

TEACHER NOTE

If some students cannot participate in this activity, they could be given the opportunity to video the activity to help the teams in the Elaborate portion of this lesson.

## Part IIb

### Explore 2/Explain 1 (60 minutes)

*Conduct an investigation to test the effect of the number of students on each side of a rope to the movement of the marker.*

14. Take the students outside to conduct their investigation.
15. Return to the classroom and provide time for the observers to look at their data sheet and make sure it is complete. Then ask a representative of each team to contribute their data to **3.4.C1: Number of Students Class Data Table**.
16. Conduct a class discussion (still in the same teams) using these leading questions:
    - Does our data match what we saw in the video? Why or why not? *ESR: Our data is different from the video because it didn't always work that the side with the most students won.*
    - Did the side with the most number of people always win? *ESR: The side with the most students did not always win.*
    - How many times did the side with the most number win? *ESR: We have 8 trials. X of the trials shown that the side with the most number of students won.*
    - How many times did the side with the least number win? *ESRs: We have 8 trials. X of the trials show that the side with the least number of students won.*
    - What patterns do you see in the data? Does something always happen (e.g., more students on one side always wins)? *ESR: The pattern is not predictable because the data shows sometimes the number of students on a side wins and sometime they do not.*
    - Are there multiple trials for the data? How many data points do you have?
    - Are the data sufficient to make a summary statement? Were you able to control the variable (numbers)? Why or why not? *ESR: We think we can make a summary statement that says sometimes the number works and sometimes it doesn't. In our data it worked 5 times, but didn't work 3 times.*

- What evidence can we use to make a claim? *ESR: We can make a claim that a greater number of students on a side does not mean that side will win. Our evidence for that is that our data shows it didn't work 3 times out of the 8 trials.*

## Part IIc

### Explore 3/Explain 2 (20 minutes)

*Make observations about the effect of the size of students on each side of a rope to the movement of the marker.*

> **TEACHER NOTE**
>
> If you go outside to test the second variable, add about 45 minutes to this part.

17. If the variable of the number of students didn't cause the team to win, what other variables can we test? Look at the list that was generated and select the variable of size. Ask students to predict the outcome if size matters (e.g., the marker will move in the direction of the bigger kids).
18. Ask students how they can investigate size without going outside. Hopefully someone will suggest the video. If they don't, ask them to recall what they saw in the video, and then replay it.
19. Conduct a discussion with what they noticed. *ESRs: I observed that the side with the larger kids lost. Therefore, I think participant size doesn't seem to matter.*

> **TEACHER NOTE**
>
> If the class agrees that participant size doesn't matter, then go to the next step in the lesson. However, if the students recognize that this is only one trial, acknowledge that they are correct. Explain that the class will play the game again to test this idea.

## Part IId

### Explore 4/Explain 3 (60 minutes)

*Conduct an investigation to test the effect of the strength on each side of a rope to the movement of the marker.*

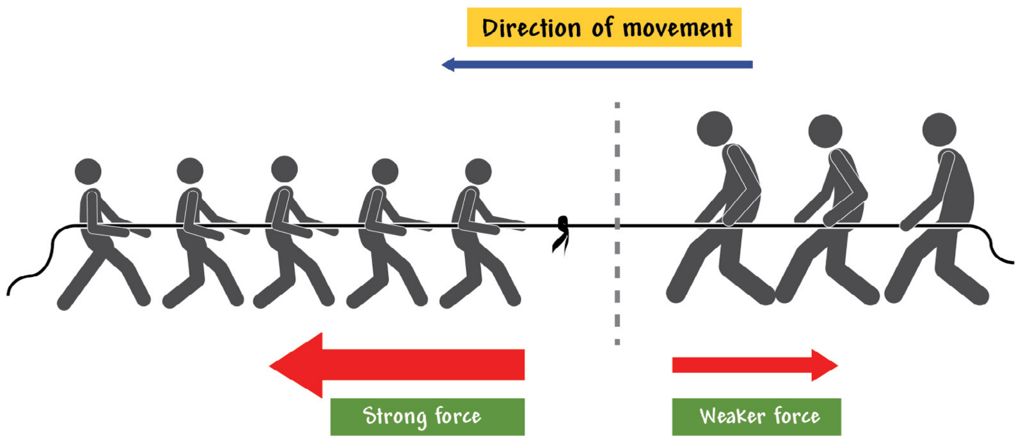
20. Ask students which variables have they identified as not an important factor in the tug-of-war game (number of students on a side; size of students on the rope). What strategies have we learned from the other lessons that can help us understand what is going on in the tug-of-war game? Hopefully they will say models and discuss how drawing arrows to represent the forces and direction might help explain the tug-of-war game.

21. Have students review **3.2.C1: Observable Features of Models** (from Lesson 2: Forces Move Objects). Replay the Tug of War video again. Ask students to work with a partner to make a model.

22. Ask partners to share their model with the table. The table group uses their whiteboard to make a consensus model with an explanation that includes what they learned from the two previous investigations (number of students, size).

23. As table groups are constructing their model, walk around the room and find one or two models for table groups to share.

    *ESR:*




Explanation: the marker is pulled in the direction of the strongest force. We learned that the number of kids on each side don't always affect the strength and that the size of the participants doesn't mean they can pull with more force.

TEACHER NOTE

Make sure the model shows the direction of the marker. It must also include an explanation about the strength force that caused the movement and not that it is the number of students on the sides of the rope (since they discarded that idea in the investigation).

24. Ask table groups to share their models, and have table groups compare each model shared with their model. Discuss the direction in which the marker moved.

    Leading Questions:

    - What do you notice about the arrows and labels in this model? *ESRs: I noticed the direction arrow and strength arrow go the same way. I noticed the stronger strength arrow was bigger than the weaker strength arrow.*

- What evidence do you have that it is the strength of the force and not the number or size of the students? *ESRs: I know it wasn't the number of kids since we have different results in our investigation data.*
- How does your model show the strength and direction of the forces? *ESRs: My model shows the bigger strength with a bigger arrow.*
- How does your model indicate balanced and unbalanced forces? *ESRs: I have two arrows that are not equal sized to show that they are unbalanced.*

25. Ask the class to predict how strength affects the movement of the marker. Based on this prediction, ask how they would modify their original tug-of-war game to test for strength. *ESRs: Keep the original plan for team A, B, C, D, but this time think about strength and who should go on each side of the rope. Have teams A/B and C/D, each determine one team you think will be strong but less players on it and then one team they think will not be as strong. Each team has 2 trials; now record data on **3.4.H2: Strength Data Table**.*
Ask observers to watch for strength and direction that the marker moves.

26. Hand out **3.4.H2: Strength Data Table** and take teams outside again. Have teams A/B divide their players into two teams—one they think will be strong but has few players on it and one that they think will be not as strong but has more players on it.
Have team C/D do the same thing. Ask teams A/B to have their "strong" team go to one side of the rope and teams C/D "not as strong" team go to the other side of the rope.

27. When teams are ready, ask them pick up the rope and yell, "start." When you yell "stop," the teams will drop the rope. Record the results on **3.4.H2: Strength Data Table**. Switch teams and repeat the investigation.

28. After returning to the classroom, ask a representative of each team to contribute their data to **3.4.C2: Strength Class Data Table**.

29. Conduct a class discussion. Use these leading questions:

- What was the configuration of the different teams? *ESR: The configurations were _____, _____, and _____.*
- How many teams had the same configuration (e.g., girls vs. boys) but got different results? *ESRs: Sometimes the same configurations had different results.*
- What does that tell you about the variable that caused the motion?
- What patterns do you see in the data? Does something always happen? (e.g., it didn't matter what the configuration of the team was, the side with the greatest strength moved the marker) *ESRs: The pattern is predictable because the data shows the side with the greatest strength always won.*
- Are there multiple trials for the data? How many data points do you have? *ESRs: We had 4 trials to compare data.*
- What evidence can we use to make a claim? *ESRs: Our evidence is that our data shows whoever was able to pull the rope the hardest won; that the greater force moved the marker across the line.*

## Part III

### Explain 4 (60 minutes)

*Construct a tentative explanation about which variable affects the change in motion of the marker in a tug-of-war.*

30. Scientists use their data to create evidence for their claims. How can we write a tentative explanation about which variable is most likely to affect how the rope moves in a tug-of-war?

> **TEACHER NOTE**
>
> If this is the first time your students have written an explanation with a claim and evidence, guide them to understand:
>
> - a claim is a statement supported by evidence that answers a question
> - evidence is supported by data
> - evidence needs to be adequate and sufficient to support the claim
> - there should be more than one source of evidence

31. Ask students to write the question in their science notebook that they were trying to answer. Ask a couple of students to share their questions. Use their ideas to create a class question (e.g. What factors/variables cause the rope marker to move in a tug-of-war?).

> **TEACHER NOTE**
>
> Emphasize the crosscutting concept of Cause and Effect while having the discussions about:
>
> - the questions students are trying to answer
> - the way they write their claim (Step 32)
> - the evidence identified from the trends in the data (Step 33)

32. Provide a sentence starter for students to write a claim in their science notebook.

    My claim is _____.

    Ask partners to share what they wrote in their science notebook and allow them to edit based on their sharing. *ESRs: My claim is that strength is a factor that causes the marker to move in a tug-of-war. My claim is that the number of students on one side does not cause the marker to move in a tug-of-war. My claim is that the marker moved because one side pulled harder. My claim is that the marker moved because there was a stronger force on one side. My claim is that the marker moved because there was a strong unbalanced force on one side.*

33. When scientists make a claim, they need to support it with evidence. Ask partners to think of evidence statements that support their claim. Encourage them to use this sentence frame:

    The evidence that supports my claim is _____. Another piece of evidence is _____.

    *Expected Student Responses (ESRs):*

    - *The evidence that supports my claim is our data showed that the number of students on each side did NOT affect the movement of the marker.*
    - *The evidence that supports my claim is that the video showed the smaller students moving the marker, so participant size does NOT affect the movement of the marker.*
    - *The evidence that supports my claim is our data showed that no matter who was on the sides of the rope, the side that used a stronger force caused the marker to move.*
    - *The marker moves in the direction of the stronger force because a bigger force was applied to that side.*

34. Ask students to share their evidence statement with the whole group. Try to elicit several different statements. Then ask, "Does anyone have a different evidence statement?" Write the statements on sentence strips and post on the class whiteboard. Group and review the evidence statements. Ask students if they want to modify any or add any new ideas.

35. Explain that scientists not only gather evidence from investigations, they also can gather evidence from media (e.g., reading text, viewing drawings, and watching videos). Today, students will have a chance to watch a video to see what other information that can be used as evidence in their explanation.

36. Ask students to take notes in their science notebook as they watch the Unbalanced Force video. **STOP AT 1:15** (after the forces in many directions acting on the barrel) because the rest of the video covers middle-school concepts.

37. Give students time to review their notes. Then ask if there were any pieces of evidence they saw/learned in the video that could support their claim. Chart their ideas and ask students to add information to their claim and evidence statements. *ESRs: The video showed if the forces were equal they were balanced, and the rope did not move. The video showed that when one team pulled harder, the forces were not equal, and the rope moved. The rope moving looked like what happened when we tested the strength variable.*

    **TEACHER NOTE**

    The media input must be played AFTER the students had explored their ideas. The video is used to support students as another piece of evidence, and also support students who are still struggling with the concepts or vocabulary and need to experience it in a different way.

38. Have a couple of students share their final claim and evidence statements using the document camera.

TEACHER NOTE

▶ These explanations can be used as a formative assessment to see if students can transfer their learning from basketball and soccer about forces, the direction of forces, and force strength to the tug-of-war.

## Part IV

### Elaborate/Evaluate (90 minutes)

*Design a process for a new tug-of-war game that uses the cause and effect of the strength of unbalanced forces on the outcome of the game.*

39. Now that the students have some understanding about force and motion as it applies to a tug-of-war, they are ready to think about their design for the new playground. Explain that engineers develop new tools, new products, and sometimes even new processes.

40. The students' challenge is to develop a process by writing new directions for a tug-of-war game between kindergartners and third graders in which both of these can happen:

    a. the kindergarten team, though challenged, will win

    b. the kindergarten team and third grade team will have a draw (neither team moves the marker)

41. Display **3.4.C3: New Game Direction Rules**. In their directions for the game, table groups must include how the following science ideas are used to design the game:

    - An object has many forces acting on it.
    - Forces have strength and motion.
    - If forces on an object are equal, the forces are balanced.
    - If forces on an object are unequal, the forces are unbalanced.
    - An unbalanced force on an object at rest will cause it to move.
    - An unbalanced force on an object that is moving can cause it to stop.
    - Unbalanced forces cause changes in the object's direction of motion.

42. The directions must include a drawing of the forces acting on the tug-of-war when the kindergartners win and when the tug-of-war is a draw.

43. Once the students understand their challenge, have them work in pairs to think about challenge A (kindergartners win) and sketch a force diagram. Then have partners share at their table. Have the table create a consensus diagram. From that diagram, have the table group write the directions for this game on poster paper and draw a model.

44. Partner table groups and have them share their directions. One table group shares while the other writes their feedback on sticky notes. Then the other group shares, and the first group writes their feedback on sticky notes. Use these student feedback prompts:

    For each poster, provide your classmates with feedback using sticky notes using one of the following stems:

    I agree with _____.

    I wonder _____.

    This makes me think _____.

    I disagree because _____.

45. Ask table groups to return to their table, review the comments on sticky notes, and make any edits to their directions.

46. Repeat this process (Steps 41 – 4 5) with Challenge B where the result of the game is a draw.

**Sample Directions for Challenge A (kindergartners win)**

Decide how many kindergartners are on one side and how many third graders are on the other side. *ESRs: I know to move the marker, I need to unbalance the forces by having a greater force on the kindergartner side. If I increase the number of kindergarten kids, they will have more strength than just a few third graders.*

> <u>Model with arrows in different directions due to a greater or lesser force. Use a large arrow for the stronger force and a smaller arrow for the weaker force.</u>

Line up the kindergartners closer to the flag; make the third graders move a couple of feet away from the flag. *ESRs: I know that a strong unbalanced force can change the direction of motion. I know that a strong force can move things farther. If the flag is closer to the kindergartners, they don't have to pull as hard to make the flag cross the line. If the third graders are farther back, they have to pull really hard.*

> <u>Model with arrows showing the distance traveled that match where the stronger force is.</u>

Make sure the rope is not too fat. *ESRs: the kindergartners need to be able to grab unto the rope and use the full strength in their hands and arms to cause a strong unbalanced force.*

**Sample Directions for Challenge B (draw)**

Decide how to make the forces equal on both sides of the rope. Let students know that they can experiment two times, and then they must decide who is on what side. *ESRs: I know that I can use patterns to predict future motion, so if I try my ideas, I can see the pattern that works best.*

You can choose to use different numbers of players or have enough students with strength on one side to equal the strength on the other side. *ESRs: I know that for the marker to NOT move, the forces acting on it must be equal or balanced.*

Model with arrows going in different directions that are the same size, showing that the forces are equal.

47. Identify several posters that address the science concepts in their directions. Use these posters to review with the class about force and motion so that they are ready for their design challenge in the next lesson.

Return to **3.1.C3: Tug-of-war** (from Lesson 1: Movement on the Playground) and ask students if they have answered the science behind some of their questions.

▶ Collect the posters from each table for Challenge A and B to use as an assessment of learning. Review the student directions and science cause-and-effect statements for:

An object has many forces acting on it.

Forces have strength and motion.

If forces on an object are equal, the forces are balanced.

If forces on an object are unequal, the forces are unbalanced.

An unbalanced force on an object at rest will cause it to move.

An unbalanced force on an object that is moving can cause it to stop.

Unbalanced forces can cause changes in the object's direction of motion.

The student directions must include a drawing of the forces acting on the tug-of-war when the kindergartners win and when the tug-of-war is a draw. Evaluate the drawings of the forces acting on the tug-of-war when the kindergartners win and when the tug-of-war is a draw. Determine which ideas students are understanding and which ideas they are not understanding to modify how you begin the next lesson.

## References

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# Number of Students Class Data Table

| Team Trial # | Number of students to the left of the marker | Number of students to the right of the marker | Who won |
|---|---|---|---|
| A/C trial 1 | | | |
| A/C trial 2 | | | |
| B/D trial 1 | | | |
| B/D trial 2 | | | |
| A/D trial 1 | | | |
| A/D trial 2 | | | |
| B/C trial 1 | | | |
| B/C trial 2 | | | |

# Strength Class Data Table

| Team<br>Trial # | Description of students to the left of the marker | Description of students to the right of the marker | Size and direction of strength arrow and direction of movement | Observations |
|---|---|---|---|---|
| Trial 1<br>A/B Strong<br>C/D Not as Strong | | | | |
| Trial 2<br>A/B Strong<br>C/D Not as Strong | | | | |
| Trial 1<br>A/B Not as Strong<br>C/D Strong | | | | |
| Trial 1<br>A/B Not as Strong<br>C/D Strong | | | | |

## New Game Direction Rules

Directions must include how the following science ideas are used to design the game:

- An object has many forces acting on it.
- Forces have strength and motion.
- If the forces on an object are equal, the forces are balanced.
- If the forces on an object are unequal, the forces are unbalanced.
- An unbalanced force on an object at rest will cause it to move.
- An unbalanced force on an object that is moving can cause it to stop.
- Unbalanced forces cause changes in an object's direction of motion.

Directions must also include a drawing of the forces acting on the tug-of-war when the kindergartners win and when the tug-of-war is a draw.

# Number of Students Data Table

| Team Trial # | Number of students to the left of the marker | Number of students to the right of the marker | Observations |
|---|---|---|---|
| A/C trial 1 | | | |
| A/C trial 2 | | | |
| B/D trial 1 | | | |
| B/D trial 2 | | | |
| A/D trial 1 | | | |
| A/D trial 2 | | | |
| B/C trial 1 | | | |
| B/C trial 2 | | | |

# Strength Data Table

| Team<br>Trial # | Description of students to the left of the marker | Description of students to the right of the marker | Size and direction of strength arrow and direction of movement | Observations |
|---|---|---|---|---|
| Trial 1<br>A/B Strong<br>C/D Not as Strong | | | | |
| Trial 2<br>A/B Strong<br>C/D Not as Strong | | | | |
| Trial 1<br>A/B Not as Strong<br>C/D Strong | | | | |
| Trial 1<br>A/B Not as Strong<br>C/D Strong | | | | |

## Next Generation Science Standards (NGSS)

This lesson is building toward:

| PERFORMANCE EXPECTATIONS (PE) | |
|---|---|
| **3-PS2-1** | Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object. [Clarification Statement: Examples could include an unbalanced force on one side of a ball can make it start moving; and, balanced forces pushing on a box from both sides will not produce any motion at all.] [*Assessment Boundary: Assessment is limited to one variable at a time: number, size, or direction of forces. Assessment does not include quantitative force size, only qualitative and relative. Assessment is limited to gravity being addressed as a force that pulls objects down.*] |

NGSS Lead States. 2013. Next Generation Science Standards: For States, By States. Washington, DC: The National Academies Press.

### SCIENCE AND ENGINEERING PRACTICES (SEP)

**Planning and Carrying Out Investigations**

- Evaluate appropriate methods and/or tools for collecting data
- Make observations ~~and/or measurements~~ to produce data to serve as the basis for evidence for an explanation of a phenomenon or to test a design solution.
- Make predictions about what would happen if a variable changes.

**Developing and Using Models**

- Develop and/or use models to describe and/or predict phenomena.

**Constructing Explanations and Designing Solutions**

- Construct an explanation of observed relationships
- Use evidence (e.g., ~~measurement~~, observations, patterns) to construct or support an explanation or a design a solution to a problem
- Apply scientific ideas to solve design problems

### DISCIPLINARY CORE IDEAS (DCI)

**PS2.A: Forces and Motion**

- 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.
- 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.

# Appendix 3.4

| CROSSCUTTING CONCEPTS (CCC) |
| --- |
| **Cause and Effect** |
| • Students routinely identify and test causal relationships and use these relationships to explain change. They understand events that occur together with regularity might or might not signify a cause and effect relationship. (3–5 Progression) |
| **Patterns** |
| • Patterns of change can be used to make predictions. |



## Common Core State Standards (CCSS)

| CCSS ELA READING |
| --- |
| **CCSS.ELA-LITERACY.RI.3.3**<br>Describe the relationship between ~~a series of historical events~~, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect. |
| **CCSS ELA WRITING** |
| **CCSS.ELA-LITERACY.W.3.8**<br>Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories. |
| **CCSS ELA SPEAKING AND LISTENING** |
| **CCSS.ELA-LITERACY.SL.3.1**<br>Engage effectively in a range of collaborative discussions ~~(one-on-one, in groups, and teacher-led)~~ with diverse partners on grade 3 topics and texts, building on others' ideas and expressing their own clearly. |
| **CCSS.ELA-LITERACY.SL.3.4**<br>Report on a topic or text, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable level. |

# Appendix 3.4

## California English Language Development (ELD) Standards

| CA ELD | | |
|---|---|---|
| **Part 1.3.6** Reading/Viewing Closely | | |
| **EMERGING** | **EXPANDING** | **BRIDGING** |
| Describe ideas, phenomena (e.g., insect metamorphosis), ~~and text elements (e.g., main idea, characters, setting)~~ based on understanding of a select set of grade-level texts and viewing of multimedia with substantial support. | Describe ideas, phenomena (e.g., how cows digest food), ~~and text elements (e.g., main idea, characters, events)~~ in greater detail based on understanding of a variety of grade-level texts and viewing of multimedia with moderate support. | Describe ideas, phenomena (e.g., how cows digest food), and text elements (e.g., main idea, characters, events) in greater detail based on understanding of a variety of grade-level texts and viewing of multimedia with light support. |
| In addition to the standard above, you may find that you also touch on the following standard in this lesson as well:<br>**P1.3.1** Exchanging information and ideas. Contribute to class, group, and partner discussions, including sustained dialogue, by following turn-taking rules, asking relevant questions, affirming others, and adding relevant information.<br>**P1.3.9** Plan and deliver brief oral presentations on a variety of topics and content areas. | | |