Sample Grades 3 - Physical Science

Knowing Science
3-DIMENSIONAL TEACHING & LEARNING

1.4 Balanced and Unbalanced Forces

PURPOSE

In previous lessons, students have learned that a force is a push or pull that causes an object to move, changes its direction, or slows or accelerates its movement. In this lesson, students learn that forces are also responsible for keeping an object in mechanical equilibrium, or state of rest. To illustrate the concept of forces in balance, students will play a game that involves students pulling with equal force on ropes attached to a ring, so that the ring does not touch a cone placed on a straight line. Understanding that balanced forces keep objects at rest will reinforce the idea that unbalanced forces cause motion.

OBJECTIVES

By the end of the lesson, students will be able to:

- Explain that if an object is at rest, two equal forces in opposite directions will cause the object to stay at rest
- Explain that when two forces are applied to an object, motion results when the forces are not equal, or not applied in opposite directions

VOCABULARY

Introduce the following words during the course of the lesson. Make sure students have many opportunities to see the words in the classroom environment and to use the words as part of the lesson. There are definitions of the words at the end of the teacher's manual and in the optional *Student Activity Book*.

- Balanced
- Direction
- Force
- Unbalanced

PREPARING FOR THE LESSON

1. Before *Session 1*, find a clear floor space for students to play a tug of war game. A school corridor, for example, should allow enough space for all the students to participate in the activity. Students may become very competitive during the tug of war and the push of war games. If the competition becomes too intense, be prepared to intervene and stop the activity.
2. Before *Session 2*, find a clear floor space to prepare a set of perpendicular lines: place the first string in a straight line on the floor and secure with masking tape; place the second string in a straight line to intersect the middle of the first line perpendicularly.
   Before starting with the Tug of War cone, remove the strings from the ring without the spring scales. During the session you will add the other two strings to the ring one by one. When the ring with the spring scales is used with two students, ask two more volunteer to hold without pulling the other two strings. When three students are pulling, a fourth student should hold the fourth string without pulling.

Session 1: What is the difference between balanced and unbalanced forces?
Time: 40-45 minutes
Materials: • Tug of War & Push of War kit • Balanced/unbalanced machine kit • Masking tape
Session 2: How can we create balanced forces that keep an object at rest?
Time: 40-45 minutes
Materials: • *Knowing Science* Tug of War Cone kit • Spring scale (10 N) • String and masking tape • *Activity Sheet 1: Balancing Forces*

TEACHING THE LESSON

Session 1: *What is the difference between balanced and unbalanced forces?*

Engage-Explore: Balancing pushes and pulls

1. Invite students to follow you to the corridor, and divide them into two teams. Make sure there are the same number of students on each team, and that the two teams are approximately of equivalent strength. Ask each team to hold the rope from the ***Tug of War & Push of War kit*** without exerting any force. Attach a ribbon or a string to the middle of the rope between the two teams., Sse masking tape on the floor to indicate the initial position of the ribbon.

2. Now, ask the students to start the completion. While students are pulling the rope, ask **"Is this a push or a pull?"** [Pull.] If you notice that one team is stronger than the other, try to address the situation by exchanging some students for others on the teams. Then restart the game. When the two teams are even, the ribbon will not move much. While the ribbon is not moving ask, **"Why is the ribbon not moving?"** [We are even; each team is pulling with the same amount of force.]

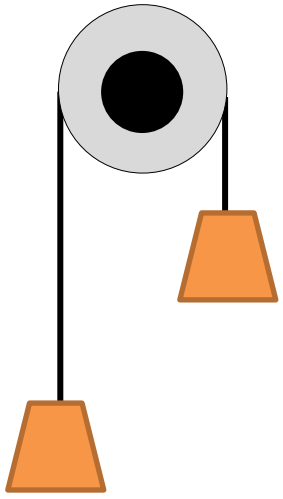
> **NOTE: Students may become extremely competitive during the tug of war game. To make sure they focus on the concept of balanced forces rather than on the intensity of competition, help one of the teams or place your hands on the rope, one on each side of the ribbon, and hold tightly to make sure the ribbon is not moving.**

3. Now ask the two teams to push. Students may react with surprise but should realize quickly how to push until the two teams collide. Students will realize that is not possible to push on a rope because the rope is not rigid. Ask to the two teams to hold the pole in the ***Tug of War & Push of War kit*** and, once in place, start pushing against each other. Guide them to see that, as in the case of the rope, there is no movement if the opposing forces are of the same magnitude.

Explore-Explain: Balanced forces

4. Explain that when two forces are pulling away, or pushing toward each other with the same force, the two forces are balanced. When forces are balanced, there is no motion.

5. Show students the *Balanced/Unbalanced Machine*, and the two equal masses in the kit. Explain that these two masses are equal in weight and hang them on the string hanging from the pulley.



6. Ask a volunteer to rearrange the two weights, placing one closer to the ground, and the other closer to the pulley. When the student releases the masses, they will not change their position. Ask another volunteer to choose a different arrangement. Again the masses will not move from their new position. Explain that, as in the tug of war game, the two weights are pushing with the same force, so the weights are balanced, and there is no movement.

Engage-Explore: Unbalanced forces

7. Repeat the tug of war activity. Use the same "balanced teams" from before. This time the objective is to introduce unbalanced forces, so chose a team, and ask one student at a time to leave it. This operation will create unbalanced forces because the team with fewer students will not be able to apply the same force as the other team. Ask, **"Is the ribbon moving? Why?"** [The ribbon is moving because one team is stronger than the other.] Explain that "pulls" in this case are different, the forces are not balanced.

Explore-Explain: Unbalanced forces

8. Return to the Balanced/unbalanced machine. Replace one of the two masses with the bigger mass in the kit. Hang and hold the two masses and ask **"What will happen if I release**

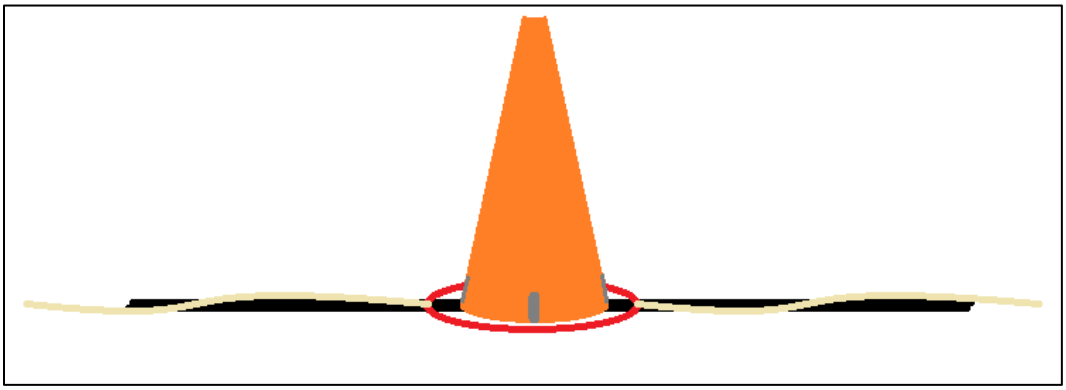
the two masses?" [The heaviest will go down, and the lightest will go up.] Release and show that the heaviest moves downward while the lightest moves upward. Ask a volunteer to rearrange the placement of the two masses. Once again the two masses will move. Explain that this, as in the previous tug of war game, is an example of unbalanced forces. Unbalanced forces cause movement.

9. Conclude the lesson by reminding students that the previous lesson focused on force as a push or pull that gets an object at rest going. Then say, **"Very often a push or pull does not move an object."**
    a. When two or more forces act on an object so it does not move, we say that the forces are balanced. When an object moves as a result of a push or a pull, we say that the forces on the object are unbalanced.
    b. With the students working in pairs, ask them to come up with a list of five examples of balanced forces acting on an object and five examples of unbalanced forces acting on an object. When the pairs have completed their work, share the lists with the whole class and verify that that the examples have been correctly classified.

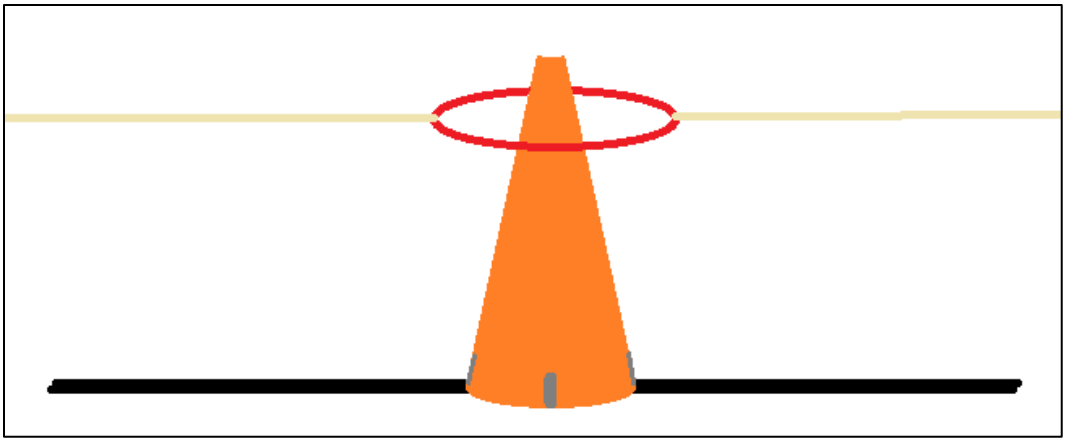
Session 2: *How can we create balanced forces that keep an object at rest?*

Explore: Balanced forces

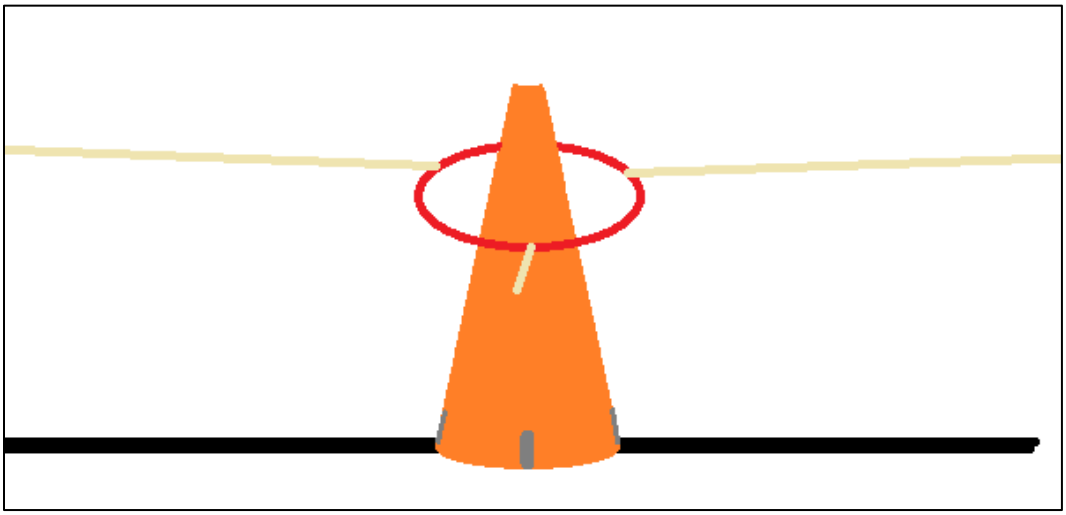
1. Set up the ***Tug of War Cone kit***. Place the cone at the intersection of the straight lines you have prepared before class, with the tape strips on the cone lined up with the masking tape lines on the floor. Attach two ropes to opposite sides of the ring, and place the ring over the cone.



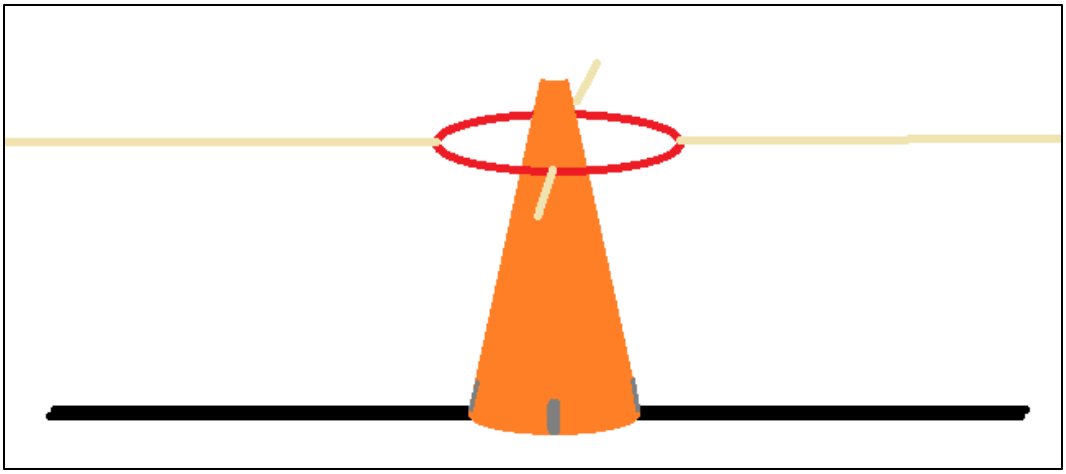
2. Explain to the class that they are going to play a game that requires them to keep opposing forces in balance. Point out the intersecting straight lines on the floor that you created with masking tape. (Tell them that a straight line has no curves, and theoretically stretches endlessly in either direction.)
3. Game procedures:
    a. Tell students that the object of the game is to raise the ring gently toward the top of the cone without the ring touching the cone.
    b. Ask two students to stand at either end of the straight line. Invite each one to pick up a rope attached to the ring, and ask them to pull gently and steadily on their ropes until they lift the ring without the ring touching the cone. They must continue to stand on the straight line. When they successfully balance one another's force, the ring will not touch the cone. Say to the class, **"Both the students are applying force to the ring. Why is the ring not moving?"** [They are applying equal force in opposite directions, so the ring stays still and does not touch the cone.]



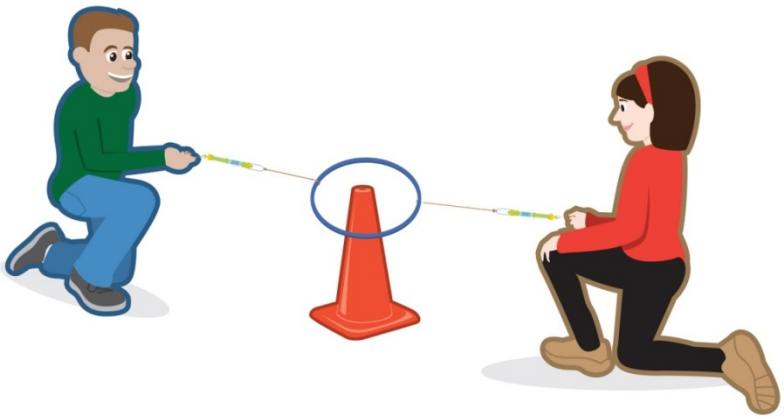
c. Attach a third rope to the ring at a 90° angle to the first two ropes. Ask another student to stand on the line at right angles to the first line and to start gently pulling on the third rope. Ask the class to observe what happens. (The ring will hit the cone or knock it down.] Say, **"Why did the ring touch the cone (or knock it down)?"** [The forces are not balanced.]



d. Attach a fourth rope to the ring at a 90° angle to the other ropes. Invite a fourth student to stand on the line opposite the third student. Direct the four students to pull gently and steadily and raise the ring until it does not touch the cone. Ask the class to observe what happens. [Opposing forces are once again in balance and the ring does not touch the cone. The fourth student has balanced the pull of the third student.]



4. Say: **"Until now, you have applied forces and felt the strength of a force in comparison with another. How can we measure forces?"** Let the students share their thoughts, and listen to what they have to say. Remind students that to measure the length of an object we can use a ruler, which is an object with very specific length (the ruler is divided into centimeters of inches). Therefore to measure length we need to define a very specific length to use as standard. To measure forces the procedure is not different. We define a very specific amount of force to be our standard. Show students the 10N spring scale (make sure to show students the scale in Newtons (N), not the one in grams). Circulate around the classroom and show students where 1 Newton (1N) is on the scale. Ask students to hold the spring scale and pull until the scale measure 1 Newton and hold. What they are feeling pulling the spring is our standard force, a force of 1 Newton.
5. Replace the ring previously used with the one with the spring scales. Repeat the previous activity, using four students to handle the ropes plus a fifth student to record the data. (Ask the students to not pull too hard so the scale does not go out of range, and make sure that one of the opposite pairs of students pulls harder to have two different pairs of equal opposite forces.) Help them record the measures on *Activity Sheet 1: Balancing Forces* reminding the students to not forget to write the unit (N).



   Try to give all class members a chance to engage in the activity and record their own data. If this is not possible, ask students to use the data from the first set of measures.
6. Ask students to complete *Activity Sheet 1: Balancing Forces*.

EXTENDING/REINFORCING NEW LEARNING

1. Give the students an opportunity to explore the concept of balanced forces further by having them attach five and six ropes to the ring. They then try to balance the ring around the cone without touching the cone. What do they discover? What conclusions can they draw?

ASSESSMENT

Communication

Divide the class into groups of 3-4 students. Ask them to explain to each other what adjustments they had to make in their pulling force, in the cone/ring activity, in order to balance the ring around the cone without touching the cone.

Other Possible Assessments

1. You can use the rubric such as the one that follows to assess students' learning. With some modifications, you can use the rubric for student self-assessment.

	Novice	Practitioner	Advanced
Explains that if an object is at rest, two equal forces in opposite directions will cause an object to stay at rest	Can explain with substantial help from the teacher.	Can explain with some help from the teacher.	Can explain independently and references the cone and ring activity as an illustration.
Explains that when two forces are applied to an object, motion results when the forces are not equal or not applied in the opposite direction.	Can explain with substantial teacher assistance.	Can explain with some help from the teacher.	Can explain independently using the vocabulary of the lesson and citing the example of the cone and ring activity.

2. Ask students to work in pairs or small groups, and create an activity which demonstrates that an object will remain at rest if two equal forces from opposite directions are exerted upon it.
3. *Activity Sheet 1: Balancing Forces* can be used as assessment.

CROSSCUTTING CONCEPTS

Cause and Effect: Mechanism and Explanation; Stability and Change

In this lesson, students physically explore the concept of balanced and unbalanced forces. When they engage in the cone and ring activity, they actively feel the opposing forces that keep an object at rest or precipitate its motion. In the process, they recognize that stability is a function of dynamic forces, and that a small change in the direction or magnitude of those forces can destroy the equilibrium.

SCIENTIFIC AND ENGINEERING PRACTICES

Planning and Carrying Out Investigations; Analyzing and Interpreting Data; Constructing Explanations; Obtaining, Evaluating, and Communicating Information

STANDARDS CORRELATIONS

Next Generation Science Standards

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.

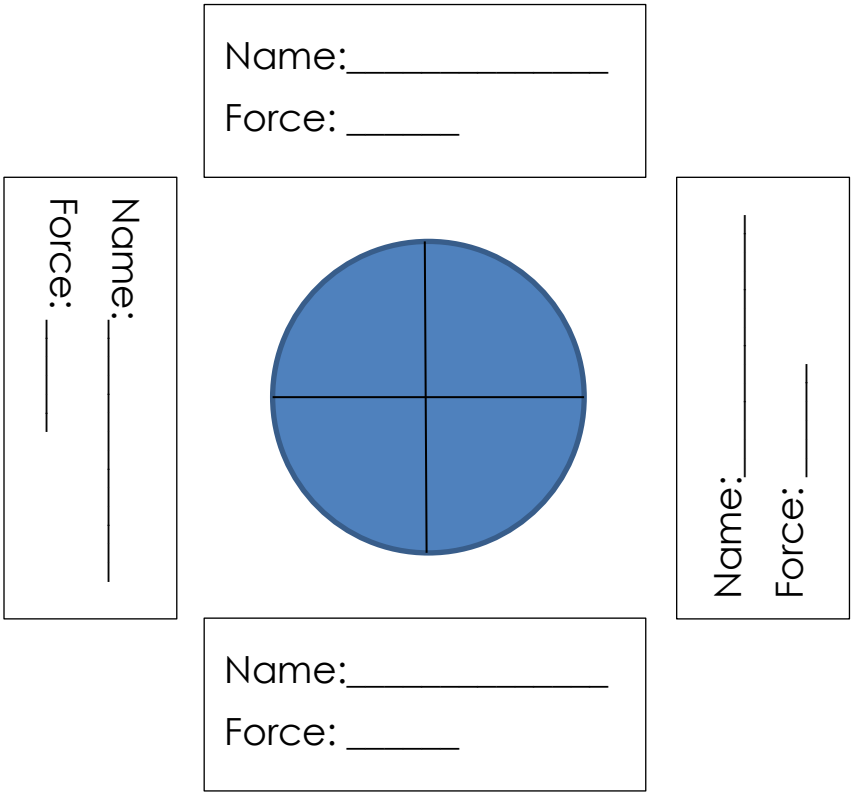
Common Core State Standards for English Language Arts

Speaking and Listening K-5

Comprehension and Collaboration: 3.1

Name _____ ***Activity Sheet 1: Balancing Forces***

Directions: Record the measured forces in the table below following the same order of students as in the activity. Then answer the following questions. Don't forget to specify the unit near each measure.



Which are the two opposite pairs?

Name_____ Force_____	Name_____ Force_____

Name_____ Force_____	Name_____ Force_____

1. What do you notice about the measured forces for each pair? Are the measurements about the same?

_____

_____

_____

_____

2. Do the forces in each pair balance?

_____

_____

3. Do balanced forces cause motion?

_____

_____

Vocabulary

Balanced: *(adj.)* Stability produced by even distribution of forces.
1.4 Balanced and Unbalanced Forces

Direction: *(noun) The line that someone or something points toward.*
1.4 Balanced and Unbalanced Forces

Force: *(noun) A push or a pull.*
1.4 Balanced and Unbalanced Forces

Unbalanced: *(abj.) Uneven distribution of forces causing motion.*
1.4 Balanced and Unbalanced Forces