

2.B.4 Balancing Crane

The Engineering Design Process in the classroom

Grade Level	2
Sessions	1 – 40 minutes 2 – 30 minutes
Seasonality	None
Instructional Mode(s)	Whole class, groups of 4–5 students, individual
Team Size	None
WPS Benchmarks	02.SC.IS.03; 02.SC.IS.04; 02.SC.IS.05; 02.SC.IS.06; 02.SC.TE.03; 02.SC.TE.04
MA Frameworks	K-2.TE.1.3; K-2.TE.2.1
Key Words	Counterweight, Crane, Fulcrum, Balance, Balance Point, Lever, Predict, System, Weight

Summary

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This lesson works in conjunction with the Balance and Motion, and Simple Machines lessons. In this activity, each student will experiment with balance and motion. To begin, the students will mimic a demonstration, initially performed by the teacher, with rulers about center of gravity and balance. Next, the teacher will demonstrate how a construction crane is a real life engineering application of balance. Then the students will use small levers to understand balance hands-on, graduating to the larger crane to solve a problem based on observations and predictions. The students will have the task of moving an object from one pod to another using the crane, requiring them to predict how to solve the problem and give an explanation based on solid evidence. The students will learn how to predict and test, as well as proper tool use and material properties. This lesson focuses on the functionality of a design.

Session 1: Balance

Summary of Session

The teacher will demonstrate the concept of balance using a yardstick, and challenge the students to prove that there is a balance point to simple objects, thereby making their own definition for balance.

Learning Objectives

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2002 Worcester Public Schools (WPS) Benchmarks for Grade 2

Students will...

1. **02.SC.IS.03** Make predictions based on observed patterns.
2. **02.SC.IS.04** Name and use simple equipment and tools to gather data and extend the senses.
3. **02.SC.IS.05** Record observations and data with pictures, numbers, or written statements.
4. **02.SC.IS.06** Discuss observation with others.
5. **02.SC.TE.03** Identify and describe the safe and proper use of tools and materials (e.g. glue, scissors, tape, ruler, paper, toothpicks, straws, spools) to construct simple structure.
6. **02.SC.TE.04** Identify tools and simple machines used for a specific purpose, e.g., ramp, wheel, pulley, lever.

Additional Learning Objectives

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Students will make connections between balance and gravity, identifying simple ways to find the balance point of certain objects.

Required Background Knowledge

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For the students...

1. The students should have some idea of what makes something balanced. Fine motor skills and an awareness of balance are not required, but helpful.

For the teacher...

1. The center of gravity is the balancing point of an object. The demonstration of finding the balance point of a yardstick is based on friction. When you support the yardstick at the very ends with two forward pointing fingers, both fingers support equal halves of the weight. As you slide your fingers together, one is moving faster toward the center than the other is. The faster moving finger leaves more of the yardstick behind it, effectively supporting more weight. This will cause the yardstick to press down more on the faster moving finger because of gravity, and the slower moving finger now moves faster than the other does. Both fingers trade moving faster and supporting more weight until you bring them to the center of the yardstick, because more weight makes more friction on the supportive finger. You will always bring your two fingers to the center (balance point) of the yardstick as long as you move them at a slow enough pace and start at equidistant positions.

Essential Questions

1. What makes an object balanced?
2. What did you predict about how to balance your ruler and can you explain why?
3. Can you come up with rules to follow to find the balance point of an object?

Introduction / Motivation

The students' motivation for this exercise is that they will have time to experiment hands-on how to find the balance point of the rulers and make their own definition for what balance is.

Procedure

Part 1

1. The teacher will introduce the general concept of balance, including vocabulary such as the balance, balance point, weight, counterweight, crane, fulcrum, lever, predict, and system.
2. The teacher will demonstrate how to find the balance point of a yardstick by slowly sliding his or her forward pointing finger from the ends of a yardstick to the center.
3. Ask the students to think why this always works with a yardstick (a symmetrical object).
4. Next, the teacher will start with two different finger positions, such as one finger at the end and the other $\frac{1}{4}$ of the way toward the center.
5. Ask the students to think about what causes this similarity in results.

Part 2

1. Give each of the students a 12-inch ruler, and ask them to predict where the balance point will be.
2. They will find the balance point of it by experimenting and testing their predictions using the same steps as in Part One, finally coming up with a definition of balance for themselves.

Materials

Materials per class	Amount	Location
Lever/Crane Kit	One	Lesson Kit

Materials per student	Amount	Location
12-inch Ruler	One per student	School Supply

Vocabulary with Definitions

1. *Balance Point/Fulcrum* – where a lever balances
2. *Counterweight* – the opposite weight that makes both sides equal
3. *Gravity* – gravitational attraction of the Earth's mass for bodies at or near its surface
4. *Predict* – to say what will happen based on what you know or think

5. *Weight* – a measure of how much gravity is pulling on something

Assessment / Evaluation of Students

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1. Can the students successfully balance their rulers, and explain why? If they cannot balance the rulers, can the students explain why not?
 2. Can the students define balance?

Lesson Extensions

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1. Introduce the concept of friction and how it is a force which both allows objects to stay in one place and slows down moving objects.

Attachments

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None

Troubleshooting Tips

–
If the students cannot replicate the teacher's yardstick demonstration with their rulers, they can try to change the start point of their fingers, slide their fingers slower, use a heavier ruler, or use the teacher's yardstick.

Safety Issues

–
None

Additional Resources

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Activity #2. Retrieved November 17, 2005, from the Power to Learn Web site:
http://www.powertolearn.com/spotlights/discovery/fun_experiments.shtml

Session 2: Problem Introduction, Prediction, and Testing

Summary of Session

The teacher will refresh the students understanding of balance, including specific vocabulary included in balancing objects. The teacher will include how engineers use balance in structures and machines they design. For reference, machines such as crane or drawbridge, and a structure would be a bridge or a balcony. The teacher should explain that engineers use balance to solve real life problems, and that the students will use a simple machine to move an object from one “pod” or place to another using balance. The students will observe relationships between weights on either end of the crane, and predict and recognize patterns as they place them on a crane.

Learning Objectives

—
2002 Worcester Public Schools (WPS) Benchmarks for Grade 2

Students will...

1. **02.SC.IS.03** Make predictions based on observed patterns.
2. **02.SC.IS.04** Name and use simple equipment and tools to gather data and extend the senses.
3. **02.SC.TE.03** Identify and describe the safe and proper use of tools and materials to construct a simple structure.
4. **02.SC.TE.04** Identify tools and simple machines used for a specific purpose.

Additional Learning Objectives

—
Students will make connections between balance and real-life engineering, such as a large crane that uses weights to balance, as well as a drawbridge.

Required Background Knowledge

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For the students:

1. The students should have some idea of what makes something balanced. Fine motor skills and an awareness of balance are not required, but helpful.

For the teacher:

1. A drawbridge or a crane is a lever where the fulcrum is not always in the middle; the length between the center of a lever (fulcrum) and the ends are the “resistance arm” and “effort arm.” The resistance arm is the side of the lever where the load you want to move is. The effort arm is the side of the lever where the effort is applied. In a crane, the effort arm is long end that extends from the fulcrum to the load. The resistance arm is the short arm (with lots of weight) which is used to balance the crane.

Essential Questions

1. What makes an object balanced?
2. What things do you know about that use balance to work?
3. How will you move the specified objects using your knowledge of balance?
4. What steps will you take to balance objects on the crane?
5. What can you predict if this object’s weight is changed?

Introduction / Motivation

The students get to decide for themselves how they will move the crane with different weights to complete the challenge.

Procedure

Part 1 (for the Teacher to demonstrate)

1. Assemble the large crane, naming the fulcrum of the crane. (Pictorial instructions are provided in the kit)
2. Balance the crane with no weight. (A cross is provided to mark the dry balance point)

3. With the crane in this balance position, rotate the crane around the fulcrum, demonstrating that the crane can move/rotate in its balance position.
4. Place 2 screws in the basket. The crane should tip toward the basket side. Move the fulcrum of the crane toward the basket, so that it balances again. (All available fulcrum positions are numbered)
5. To use the crane, place a bolt* (moved bolt noted with a *) on the floor. Remove one bolt from the basket. The magnet end will drop to the floor. Rotate the crane to “catch” the bolt* on the magnet. Place enough bolts into the basket to rebalance the crane.
6. Rotate the crane to a new position. Remove bolts from the basket to drop the magnet to the floor.
7. Remove the bolt* from the magnet, and place bolts in the basket to rebalance the crane.
8. The teacher may demonstrate this procedure again.

Part 2 (for the students to do at their desks)

1. Ask the students to take out their 12-inch ruler.
2. Provide each student with a fulcrum (small gray plastic prism) and handful of weights.
3. Ask the students to balance the ruler on the fulcrum block.
4. Allow the students to experiment with different fulcrum positions and weights.

Part 3

1. Now that the students have hands-on experience with their levers, they may use the large crane to complete the challenge of moving bolts from one pod to another.
2. Ask the students what they will do to complete the challenge, and then what they predict will happen and why, based on their observations of the teacher’s demonstration and their hands-on experience with 12-inch

levers. Specifically, where will they choose to be the fulcrum, how much weight they want to move, how much counterweight they will need, and why.

Materials

Materials per class	Amount	Location
Lever/Crane Kit	One	Lesson Kit

Materials per student	Amount	Location
12-inch Ruler	One	School Supply
“Balancing Crane” Worksheet	One	PIEE/WPI Graduate Fellows

Vocabulary with Definitions

- 1. *Balance Point/Fulcrum* – where a lever balances
- 2. *Counterweight* – the opposite weight that makes both sides equal
- 3. *Crane* – A machine for hoisting and moving objects by means of a swinging arm
- 4. *Gravity* – gravitational attraction of the Earth's mass for bodies at or near its surface
- 5. *Lever* – a simple machine that tries to move a weight through space
- 6. *Predict* – to say what will happen based on what you know or think
- 7. *Weight* – a measure of how much gravity is pulling on something

Assessment / Evaluation of Students

- 1. Can the students determine the proper placement of weights to balance the lever arm on top of the crane?
- 2. The students will identify the crane by saying: It has a base. It has arms. It has a balance point. (Name it. Hold it. Explain it. Demonstrate it.)

Lesson Extensions

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Magnetism and the Compass

Attachments

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1. Balancing Crane worksheet

Troubleshooting Tips

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The balance and crane lesson will result in trial and error, which is very common in the Engineering Design Process. It is not expected that all students will have the fine motor skills to operate the crane, which is why the teacher can help position it based on the students' directions.

Safety Issues

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1. When the students work with levers at their desks, make sure that they do not end up making catapults and launching weights across the room by directing them to slowly weight both ends.
 2. The crane will be about the same height as the students, and when they swing the arm around to aim for the pods, make sure they keep a safe distance from the weighted ends, and that no heavy weights drop on their toes.

Additional Resources

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None

Name: _____ Date

Balancing Crane

What parts of a crane can you draw?

What parts of a crane can you label?

