Potential and Kinetic Energy Lesson 2: *The Make*

Educator's Resource Guide

The Alleycats want to make sure they are bowling league champions. To help the team, students will design and conduct two investigations that test the effect of height and mass on the kinetic energy of a marble.

Objective

In *The Make*, students will:

1. Create a ramp and use spheres of different masses to recreate a bowling scenario and observe the effect of mass, height, and potential energy on a marble's kinetic energy.
2. Collect data and draw conclusions about how to maximize kinetic energy to help The Alleycats bowl their way to success.

Time Required: 120 minutes

Materials Required	**Safety Considerations**	**Science & Engineering Practices**
If doing this in person, the following materials will be for teams of 3–4. If doing this remotely, students will be doing this on their own: ● 2–3 marbles (different sizes &/or mass) ● Various books (used for ramp and to increase the height of the ramp) ● Index card ● Ruler ● Balance or scale ● Color pencils	None	● Developing and Using Models ● Constructing Explanations or Arguments From Evidence

Inquiry Scale

Level 1 (*recommended for grades 4–5)*
Demonstrate the general procedure to the class then model how to set up the investigation and how to adjust the setup for each trial. Guide data analysis.
Level 2 (*recommended for grades 5–6)*
Demonstrate the general procedure and model how to set up the investigation for one trial. Make suggestions, as needed, to encourage students to try various scenarios and analyze data to draw conclusions.
Level 3 (*recommended for grades 6–7)*
Students independently design a procedure and complete all trials. Make suggestions, as needed, to encourage students to try various scenarios and analyze data to draw conclusions.
Level 4 (*recommended for grades 7–8)*
Students independently complete all aspects of *The Make*, including setting up and conducting the investigation, gathering data, and drawing conclusions.

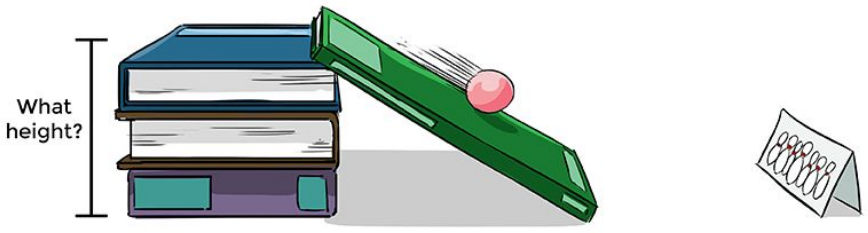
Agenda

I. Show PowerPoint to introduce the Make Activity (10–15 minutes)
The PowerPoint will review essential concepts learned in *The Solve* and provide context for students' upcoming *Make* challenge.

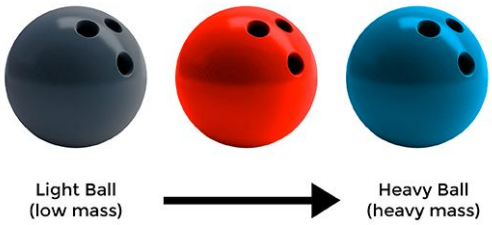
II. *The Make* Activity (120 minutes)

Introduce the challenge: Design and conduct **two** investigations to help the Alleycats become league champions! In today's challenge you'll be assembling a model of a ramp. You'll run a series of tests, collect data, and from that data, draw conclusions and report back to The Alleycats.

Investigation 1 will answer the question: **At what height should the Alleycats place the bowling ball before releasing it?**
Which height will provide The Alleycats with the most kinetic energy?



Investigation 2 will answer the question: **What should the mass of the bowling ball be?**
How does mass have an impact on kinetic energy?



Using Models

Often, when scientists can't conduct tests on the specific things they're investigating, they use models to help them draw conclusions. For example, to test how a piece of equipment works in Antarctica, a scientist might test it in the freezer first. Today, since we can't go to a bowling alley, we're going to use items to represent the bowling alley.

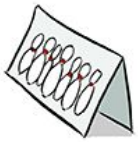
Making the Model

This guide suggests books are used to create the ramp but students can make their ramp with any materials they have available. They will also need a ruler and at least two spheres (balls) of different masses (the more spheres of different masses, the better)!

Example

In this model:

- Light marbles represent light bowling balls.
- Heavy marbles represent heavy bowling balls.
- A large book represents the ramp. Books will be added or taken away to increase and decrease the height of the ramp.
- An index card will represent the bowling pins.



If students are using different materials than those listed above, they are asked to complete the following table in their Student Guide.

Object in the Bowling Alley	**Will be represented by:**
Light Bowling Ball	
Heavy Bowling Ball	
Ramp (include how you will adjust the height of the ramp)	
Bowling Pins	

Setting up the Model

The Student Guide sets out instructions for setting up the model. These are shown below for your reference.

1. Place the index card that represents the bowling pins at this same distance for all trials. Choose a distance from the bottom of the ramp. Ideally, this will be between 3 and 5 centimeters. Record this below.
   Note: We will use "index card" through this guide to represent bowling pins, but you might be using something else to represent the bowling pins. That's OK! When reading through these instructions, just swap the index card for the material you will be using.

   My index card will be _____ cm from the bottom of the ramp each time.

2. The distance the index card moves is an indication of the amount of kinetic energy the marble (representing the bowling ball) has at the bottom of the ramp. How will these measurements help you make a recommendation to the Alleycats?

Test Question 1

At what height should The Alleycats place the bowling ball before releasing it? Which height will provide The Alleycats with the most potential energy?

The testing procedure students should follow is set out below:

- **Use the same marble each time** (keep the mass constant) and only vary the height of the ramp.
- Roll the marble down the ramp and measure how far the index card moved.
- Perform three trials at the same ramp height and at the end, calculate the average distance moved.*
- Then change the height of the ramp and carry out three more trials at that height.
- Repeat until the ramp height has been adjusted four times in total, with three trials carried out at each height.

**To calculate the average, add up the distance values for trial 1, trial 2, and trial 3. Then divide that sum by 3.*

Students complete the following data collection table in their Student Guide.

		Distance index card moved			
		Trial #1	**Trial #2**	**Trial# 3**	**Average***
A	Ramp height: 4.5-cm	13-cm	20-cm	11.5-cm	14.8-cm
B	Ramp height: 9.0-cm	19.5-cm	20.5-cm	17-cm	19-cm
C	Ramp height: 13.5-cm	22.0-cm	26.5-cm	14.5-cm	21-cm

Question 1: Conclusions

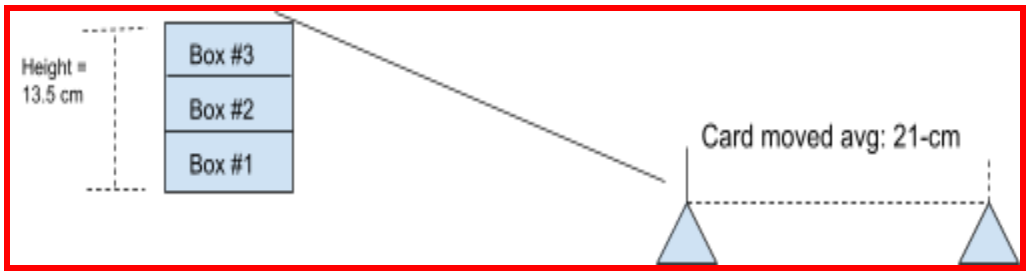
1. Which ramp height caused the index card to move the farthest?
   Answers will vary, but students should conclude that the highest ramp height caused the index card to move the farthest distance.

2. At which height did the marble have the highest potential energy? Explain your answer using evidence from your trials.
   Answers will vary but students should conclude that the marble had the highest potential energy at the highest ramp height. A model answer might be: Since potential energy increases when height increases, the most potential energy will be shown when the ramp is at its highest position.

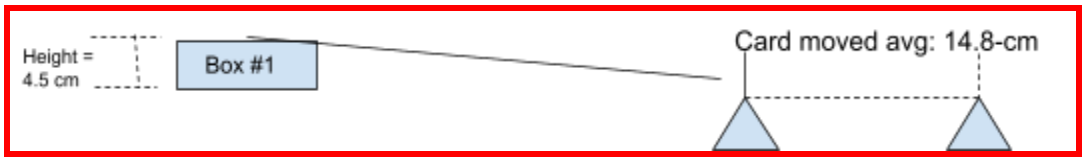
3. Why did the marble with the highest potential energy cause the index card to move the farthest?
Answers will vary, but students should conclude that the highest potential energy will become the highest kinetic energy, and the more kinetic energy an object has, the more work (moving the index card) can be done. A model answer might be:
When potential energy is increased, kinetic energy will also increase. The more kinetic energy an object has, the more work that object can do on other objects.

4. Where did the marble's kinetic energy come from?
Answers will vary, but students should conclude that the marble's kinetic energy comes from the marbles height on the ramp, or potential energy.. A model answer might be:
The marble's potential energy at the top of the ramp becomes its kinetic energy as it rolls down the ramp.

5. Sketch the investigation design in which the marble had the most kinetic energy and caused the index card to move the farthest distance. Label how far the index card moved.
Answers will vary, but students should conclude that the highest height possible is the ideal height to maximize kinetic energy. A model sketch might be:



6. Sketch the investigation design in which the marble had the least kinetic energy and caused the index card to move the least distance. Label how far the index card moved.
Answers will vary, but students should conclude that the lowest height possible is the ideal height that minimizes kinetic energy. A model sketch might be:



7. From what height should The Alleycats launch their bowling balls? Use evidence from your investigations to support your recommendation.
Answers will vary, but students should conclude that the highest height possible is the ideal height to maximize kinetic energy. A model answer mighty be:
In our experiment, the highest height of 13.5-cm resulted in the most kinetic energy, making the card move the farthest, so the Alleycats should use the highest height possible, and in our experiment, it was the height of 13.5-cm.

Test Question 2

What should the mass of the bowling ball be? How does mass have an impact on kinetic energy?

The testing procedure students should follow is set out below:

- Keep the height of the ramp constant (use the same height for all trials) and use more than one type of sphere (ideally, four marbles/balls of different mass).
- Use a balance or scale to calculate the mass of the spheres in grams. If a balance or scale isn't available, you can estimate the mass of the spheres by looking at their size and weighing them in your hands. Label the spheres based on their relative mass. If you have four spheres, label Sphere 1 as "lowest mass" and Sphere 4 as "greatest mass."
- Select the ramp height from investigation 1 that resulted in the index card moving the greatest distance. Keep the ramp at this height for all trials.
- Roll spheres of varying masses down the ramp and measure how far the index card moved.
- Perform three trials for each sphere. At the end, calculate the average distance moved.

**To calculate the average, add up the distance values for trial 1, trial 2, and trial 3. Then divide that sum by 3.*

Students complete the following data collection table in their Student Guide.

		Distance index card moved (in cm)			
		Trial #1 (time stamps)	**Trial #2** (time stamps)	**Trial# 3** (time stamps)	**Average**
A	Mass of sphere (in grams): Largest Marble (26 grams)	30 cm (0:05 s)	27 cm (0:16 s)	44+ cm (0:29 s)	33.7 cm
B	Mass of sphere: Medium Marble (22 grams)	25 cm (0:44 s)	26 cm (0:52 s)	19 cm (1:00 min)	23.3 cm
C	Mass of sphere: Small Marble (9 grams)	24 cm (1:13 s)	14 cm (1:21 s)	25 cm (1:30 s)	21 cm
D	Mass of sphere: Small Steel Sphere (5 grams)	28 cm (1:40 min)	17 cm (1:50 min)	14 cm (2:00 min)	19.6 cm

Question 2: Conclusions

1. Which sphere mass resulted in the pins moving the farthest?

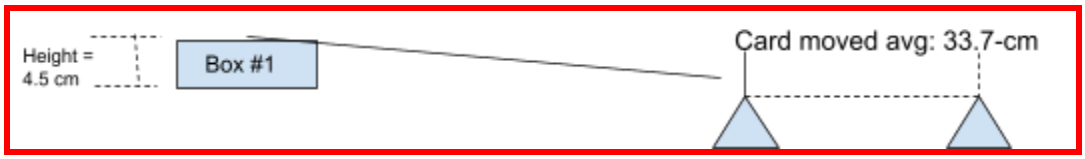
The largest marble, the heaviest sphere, caused the "pins" to move the farthest.

2. Which sphere mass resulted in the highest kinetic energy? Explain your answer using evidence from your trials.

The largest marble, the heaviest sphere, had the most kinetic energy because it moved the fastest at the bottom of the ramp. Also, since it pushed the "pins" the farthest, it means that the golf ball did the most work.

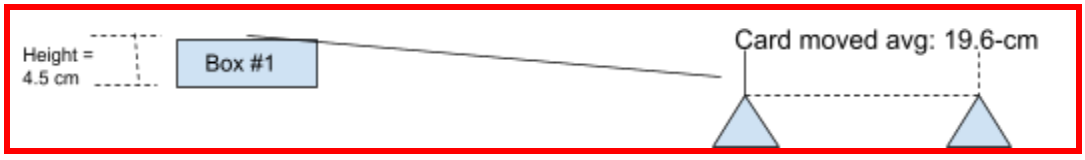
3. Sketch the investigation design in which the sphere had the most kinetic energy causing the index card to move the farthest. Label how far the index card moved.

The heaviest marble (26-grams):



4. Draw the sketch of the investigation design in which the sphere had the least kinetic energy causing the index card to move the least distance. Label how far the index card moved.

The the small steel sphere (5 grams)



5. What is the effect of mass on kinetic energy?

The heavier the mass, the farther the card moved, meaning more work was done. More work means more kinetic energy.

6. Which mass bowling ball should The Alleycats use? Use evidence from your investigations to support your recommendation.

In our experiment, the largest marble of 26 grams resulted in the most kinetic energy, making the card move the farthest, so the Alleycats should use the ball with the greatest mass available, and in our experiment, it was the marble that was 26 grams.

Bringing it All Together

After conducting their two investigations and collecting their data, students can now make their recommendations to the Alleycats on the following points.

At what height should the Alleycats place the bowling ball before releasing it?

What should the mass of the bowling ball be?

Students should use evidence from their investigations to support their recommendation.

Answers will vary, a potential conclusion statement may be:
If the Alleycats want the best conditions to win the tournament, they should use the highest height of ramp available, and also the most massive bowling ball that they can lift. The highest height will give the ball the greatest potential energy, which will become the greatest kinetic energy. And, the heavier the bowling ball, the more kinetic energy it will have.

III. Exit Ticket (10 minutes)
Students complete the exit ticket that summarizes their understanding of *The Make* and connects students to the upcoming Engineering challenge.
Note: In collaborative classrooms, this serves as the individual accountability in an otherwise group project.

Exit Ticket Answer Key

1. How did your sphere gain potential energy?
   The sphere gained potential energy by placing it at the top of the ramp.

2. How did your sphere gain kinetic energy?
   The sphere gained kinetic energy by rolling down the ramp.

3. How did mass affect the amount of kinetic energy of the sphere?
   Increasing the mass of the ball that rolls down the hill increases the kinetic energy of the ball.

***The Make* Assessment:** Project Grade and Rubric Score Sheet – Potential and Kinetic Energy

Project Submitted by _____

The Make Investigation Student Guide Checklist

Your Challenge: Design and conduct an investigation that uses data to help The Alleycats win the bowling league!

Project Completeness:

- ❏ Includes 2 investigations
  - ❏ Sphere size indicated
  - ❏ Ramp height indicated
  - ❏ Observations are included
- ❏ Conclusions are included
  - ❏ Supporting evidence is included

DCI Standards Checklist:

- ❏ Investigation of greatest kinetic energy clearly identified, sketched, and supported with data and evidence.
- ❏ Investigation of least kinetic energy clearly identified, sketched, and supported with data and evidence.
- ❏ Recommendation to The Alleycats is supported by evidence.

Science & Engineering Practices

	Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Developing and Using Models	Drawings, diagrams, or visual models include major misconceptions or have missing parts. Explanation of the model is minimal or not present.	Drawings, diagrams, or visual models include minor misconceptions or have missing parts. Explanation of the model is minimal.	Drawings, diagrams, or visual models are complete, but contain a minor misconception. Explanation of the model is complete but lacking complexity.	Drawings, diagrams, or visual models have no misconceptions and contain all details. Explanation of the model is complete and complex.
Constructing Explanations or Arguments From Evidence	Constructs an explanation with no clear sources of evidence.	Uses scientific principles and/or data from at least one source to construct or evaluate an explanation, but explanation contains minor misconceptions.	Uses accurate but incomplete scientific principles and/or data from multiple sources to construct or evaluate an explanation.	Uses accurate and complete scientific principles and/or data from multiple sources to construct or evaluate an explanation.

Teacher Comments:

Final Score: Final Grade: