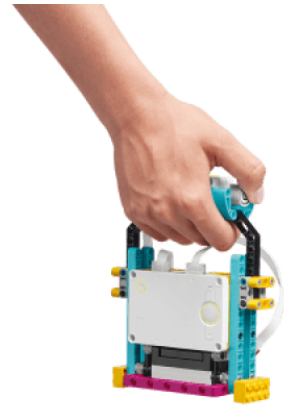


Time for Squat Jumps

Graph potential energy at the maximum height of a jump.

🕒 30–45 min. 📦 Advanced 🎓 Grades 6–8



Teacher Support

Key objectives

Students will:

- Explore ways of measuring the height of a jump
- Use that value to calculate potential energy

Things you will need

LEGO® Education SPIKE™ Prime Set

Device with the LEGO Education SPIKE App installed

Additional resources

[Building Instructions \(Kettlebell model\)](#)

[Sample data for the lesson](#)

[Student Inventor Notebook](#)

Educational standards

NGSS

MS-PS3-4

Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.

Common Core

CCSS.MATH.CONTENT.7.RP.A.2

Recognize and represent proportional relationships between quantities.

CCSS.MATH.CONTENT.7.RP.A.2.A

Decide whether two quantities are in a proportional relationship, e.g., by testing for equivalent ratios in a table or graphing on a coordinate plane and observing whether the graph is a straight line through the origin.

CCSS.MATH.CONTENT.7.RP.A.2.B

Identify the constant of proportionality (unit rate) in tables, graphs, equations, diagrams, and verbal descriptions of proportional relationships.

CCSS.MATH.CONTENT.7.RP.A.2.C

Represent proportional relationships by equations. For example, if total cost t is proportional to the number n of items purchased at a constant price p , the relationship between the total cost and the number of items can be expressed as $t = pn$.

CCSS.MATH.CONTENT.7.RP.A.2.D

Explain what a point (x, y) on the graph of a proportional relationship means in terms of the situation, with special attention to the points $(0, 0)$ and $(1, r)$ where r is the unit rate.

CCSS.ELA-LITERACY.W.7.2

Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

CCSS.ELA-LITERACY.W.7.2.A

Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information, using strategies such as definition, classification, comparison/contrast, and cause/effect; include formatting (e.g., headings)

such as definition, classification, comparison/contrast, and cause/effect; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.

CSTA

2-CS-01

Recommend improvements to the design of computing devices, based on an analysis of how users interact with the devices.

2-CS-02

Design projects that combine hardware and software components to collect and exchange data.

2-DA-08

Collect data using computational tools and transform the data to make it more useful and reliable.

2-DA-09

Refine computational models based on the data they have generated.

ISTE

4a

Students know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts or solving authentic problems.

4b

Students select and use digital tools to plan and manage a design process that considers design constraints and calculated risks.

4c

Students develop, test and refine prototypes as part of a cyclical design process.

5b

Students collect data or identify relevant data sets, use digital tools to analyze them, and represent data in various ways to facilitate problem-solving and decision-making.

5d

Students understand how automation works and use algorithmic thinking to develop a sequence of steps to create and test automated solutions.

Hybrid learning resources

[5 Ideas and examples for Blended Learning Using the 5E Model](#)

Prepare for Blended Learning

(Before Class)

- If you feel it's needed, plan a lesson using the getting started material in the app. This will help familiarize you and your students with SPIKE Prime.
- Make sure to watch the lesson video on this page.
- Read through the student material for this lesson via the link on this page, or in the SPIKE App.
- You might want to consider:
 - Choosing the right tool(s) and the right place. For example, watching videos, reading a textbook, or preparing for a hands-on experience can easily be done at home. Performing the experiment and collecting data "hands-on" is easier in a classroom setting.
 - Using a variety of tools and allowing for broad differentiation. This will increase your students' engagement and improve learning outcomes.
 - Providing various methods of virtual collaboration. Here are some examples:
 - Videoconferencing

- Blogs, chats, or wall posts
 - Digital versions of student worksheets
 - Adapting the lesson flow to account for not being a classroom setting throughout the entire lesson. We've provided an example lesson flow below.
 - Here are other ways to adapt the lesson flow to your student needs:
 - Have your students watch the videos describing what they're about to do. You can point them to the SPIKE App or use the student worksheet URL.
 - Use any other material you may have already prepared on the topic.
 - Customize the Student Inventor Book to have your students prepare their learning experience and reflect on their findings. (see Additional Resources)
 - Use the Lesson Briefs (an easy-to-use lesson overview printable 1-pager) to inspire your students with an open ended challenge. (see Additional Resources)
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Engage

(Before Class, 20 Min.)

- This lesson explores potential energy. The equation for potential energy is $E_p = mgh$. The value of "g" is known, and "m" can be found or approximated. The unknown variable in this lesson is the height of a jump, which your students will measure. They'll start by using the Distance Sensor pointing downward to measure their maximum distance from the ground as they jump (make sure they're on a flat surface). Later on, they'll explore other methods using the Hub's Acceleration Sensor.

Ignite a Discussion

Start a discussion by asking questions related to the lesson. Here are a few suggestions:

- What's *potential energy*?
- How high can you jump?
- How much (potential) energy is that?

Have your students write down their thoughts as a hypothesis.

Explore

(In Class, 30 Min.)

- Have your students build a kettlebell that can record jump-related data. They can create their own models, or follow the building instructions in the app to build the Kettlebell model.
 - Ask your students to try out their models using the suggested program.
 - Ensure that they jump in a very controlled way, **pointing the kettlebell straight toward a smooth surface (avoid rugs or carpets)**.
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Explain

(In Class, 15 Min.)

- Allow your students some time to adjust their programs to improve performance.
 - Encourage them to record as much data as possible during their experiments.
 - Have them export their data as a CSV file, they can manipulate it in other software if they wish.
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Elaborate

(After Class, 25 Min.)

- If your students still have access to their SPIKE Prime Sets, have them complete the tasks from the SPIKE App, to elaborate with hands-on learning, for example
 - Ask them to jump with more mass (e.g., by wearing a backpack), then describe their potential energy when jumping with a backpack compared to without.
 - If your students don't have access to their sets, have them complete their Student Inventor Notebook, or assign one of the extension activities suggested below. Most of the extension activities can be done using the data collected during the hands-on session
 - Facilitate a sharing session in which your students exchange information. This can be done using whichever method/tool is most efficient (i.e., in-person or online).
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Evaluate

- Give feedback on each student's performance.
 - You can use the assessment rubrics provided to simplify the process.
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Assessment Opportunities

Teacher Observation Checklist

Establish a scale that meets your needs, for example:

- Partially accomplished
- Fully accomplished
- Overachieved

Use the following success criteria to evaluate your students' progress:

- The students can program a device to log data on a line graph..
- The students can interpret the values coming from the line graph.
- The students can explain potential energy in their own words, drawing accurate connections to mass and height.

Self-Assessment

Have each student choose the brick that they feel best represents their performance.

- Blue: I can graph data using the program provided in the app.
- Yellow: I can create my own line graph and explain my results.
- Violet: I've created new experiments on my own.

Peer-Assessment

Encourage your students to provide feedback to others by:

- Having one student score the performance of another using the colored brick scale above.
 - Asking them to present constructive feedback to each other so that they can improve their performance during the next lesson. This is a great opportunity to use videoconferencing tools or blog posting tools in a blended learning scenario.
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Differentiation

Simplify this lesson by:

- Asking your students to recreate the experiment using only the Hub (and maybe the Distance Sensor)

the Distance Sensor)

- Making sure that your students adjust the suggested program in the SPIKE app to match their model configuration.
 - The data should be relevant for logging acceleration values as long as the Hub is held perpendicular to the ground

Take this lesson to the next level by:

- Asking your students to find other ways to determine the height of a jump:
 - Using the Hub's Acceleration Sensor
 - Using a video of your jump(s)
 - Using only time
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Tips

Building Tips

Coding Tips

Using Download Mode

This lesson is designed to be played in Download Mode. The Download Mode allows for a higher sample rate of data collection by the Hub. This means that the Line Graph has a better resolution. It also means that the data set has to be imported after the program has been stopped.

Using the Stop Program Block to transfer automatically data sets

Using this block will end your program and trigger automatically an upload of the collected data sets from the Hub to your device when connected via bluetooth. You need to manually upload data sets when using a USB connection.

Main Program

Science Data Tips

Here is an example of the data students can expect from this experiment.

Extensions

Math Extension

To incorporate the development of math skills:

- Instead of logging the distance between the bottom of the kettlebell and the ground directly with the distance sensor, ask your students to use acceleration values to find the height of the jump.
- Have your students use each of these methods (from measuring the distance and from calculating it from acceleration values) to find the potential energy, then describe which method they thought was the hardest or the most efficient, and why.

Note: This will require additional time.

Language Arts Extension

To incorporate the development of language arts skills:

- Ask your students to write a paper explaining what happens when someone jumps. Have them research muscular strength and biomechanics, then compare human jump performance to that of several animals.
- Have your students investigate a robot prototype that can jump, then write a paper describing how its engineers have tried to replicate muscular impulse.

Note: This will require additional time.

Career Links

Students who've enjoyed this lesson might be interested in exploring these career pathways:

- Therapeutic Services
- Engineering & Technology