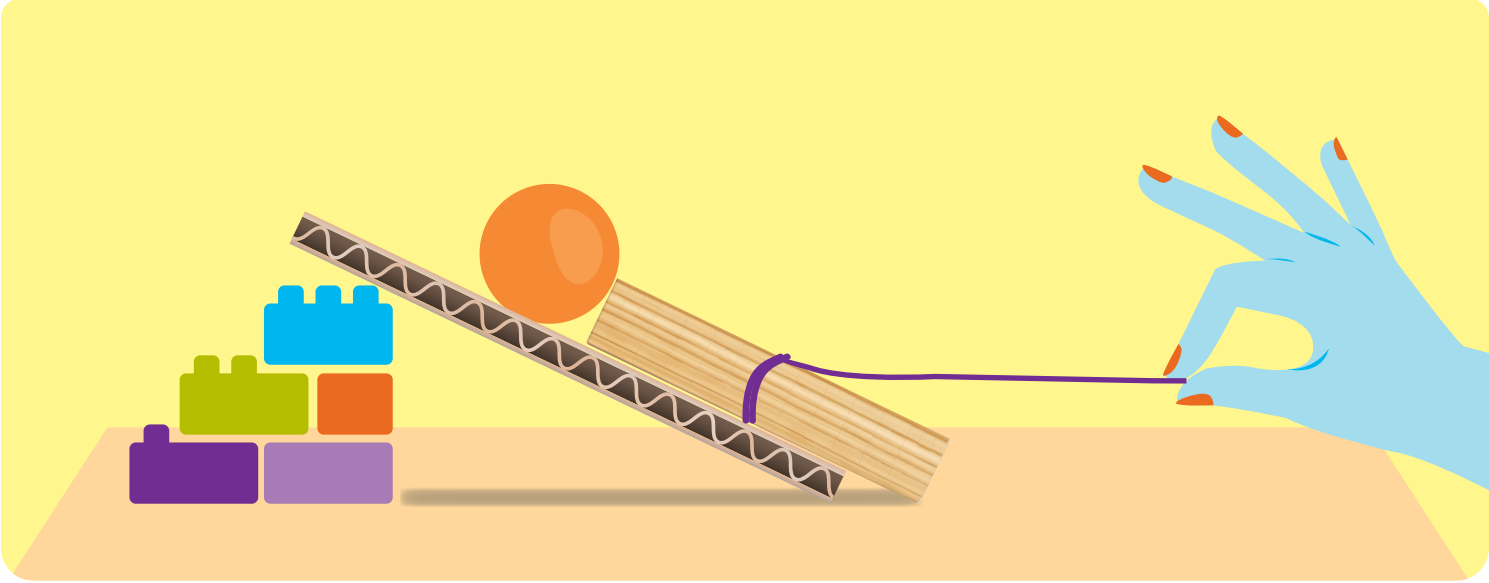
LESSON

On Your Mark, Get Set, Roll!

The Tech Challenge 2024
Grade Levels: 4-12
Two sessions (60 min each)

Students will explore how to create triggers by building a device that releases a ball when activated. Their design will need to include a trigger that can be activated from three or more feet away from the device.



Outline

Session 1: Activating Devices	**60 min**
Teams will explore how potential energy can be used as a trigger by designing and testing a device that releases a ball when activated from a distance.	
Session 2: Designing a New Trigger	**60 min**
Teams will take what they learned from the previous session to design a different trigger.	

Grade Levels: 4-12

Duration: Two sessions (60 min each)

Concepts/Skills

Energy transfer, stored energy, gravitational potential energy, elastic potential energy, engineering, release mechanisms

Objectives

Students will:

- Consider how they can use potential energy to build their triggers.
- Design a ball-release device that is activated by a trigger.
- Iterate on their design by building a different method for activating the device.

To learn more about this year's Tech Challenge, go to thetech.org/thetechchallenge

The Tech Challenge

This lesson was created to prepare students for the 2024 Tech Challenge: Cosmic Quest, presented by Amazon.

This lesson will ...

- Introduce students to triggers (release mechanisms).
- Familiarize them with stored energy and energy transfer.

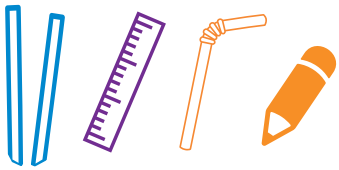
Materials and Preparation

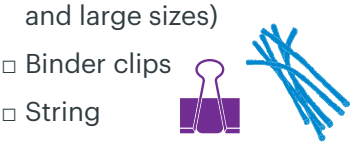
Materials

Use the table below for inspiration. Don't limit yourself to the items on this list — be creative!

Per class of ~32 students

Structural Pieces *(50+ total)*	**Long Items** *(50+ total)*	**Sturdy Items** *(10+ total)*	**Connectors** *(100+ total)*
□ Binders	□ Chopsticks	□ Pillows	□ Chenille stems (pipe cleaners)
□ Bottle caps	□ Rulers	□ Blocks	□ Rubber bands (regular and large sizes)
□ Cardboard boxes	□ Pencils	□ Textbooks	□ Binder clips
□ Cardboard sheets	□ Straws	□ Small bags of rocks or sand	□ String
□ Cardboard tubes		□ Bean bags	□ Brass fasteners
□ Clipboards			□ Masking tape (max. 3 ft or ~1 m per team)
□ Cups			
□ Food containers			





Tools *(1 set per group)*

- □ Safety glasses (for testing)
- □ Scissors
- □ Hole puncher
- □ Ball for testing
- □ *Optional: Crop-a-dile® ¼ in Power Punch*
- □ *Optional: 3 ft or ~1 m of string*

Tech Tip

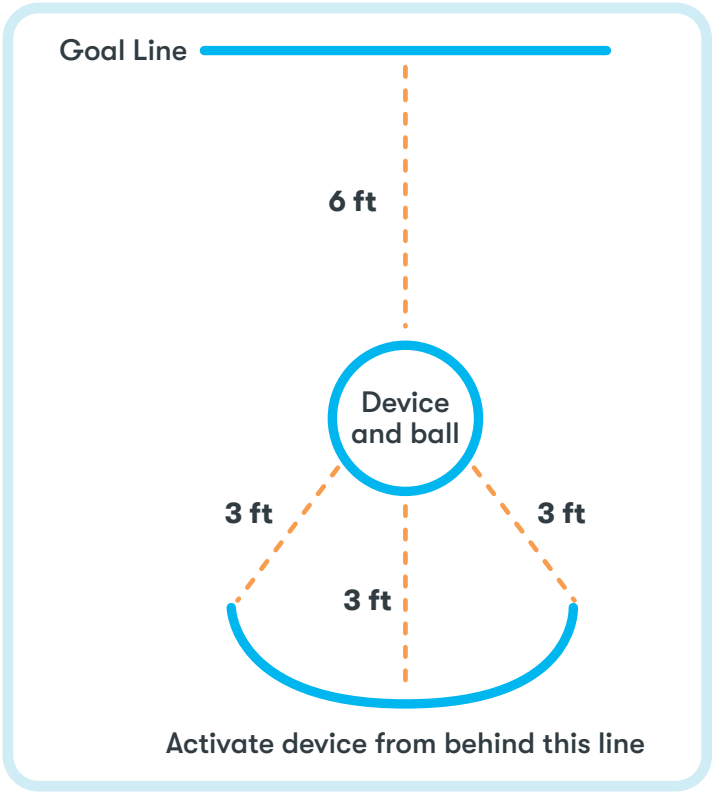
See our **educator guides and videos** for more design challenge facilitation techniques. For this lesson check out:

- Prototyping - Test, Reflect, Iterate

Testing Set-up

1. Designate a testing area in your classroom that is at least 8 ft wide (2.44 m) and 12 ft (3.7 m) long. Clear the space of any items.

   Note: If you don't have enough room in your classroom, you could run the challenge outside, in a hallway, or in a multipurpose room. If using lighter balls, you may want to consider how wind currents would affect the testing
2. From the long end of the space, measure 3 ft toward the center. Tape a circle on the floor in the middle of that area to indicate where to place the device.
3. Measure 6 ft (1.8 m) from the taped circle to the other side of the space. Tape a line here to indicate the goal line.
4. On the side of the circle opposite the goal line, tape a larger half circle. Measure so the middle and both ends of the half circle are 3 ft (.91 m) away from the circle.



Classroom Adaptation

If you do not have access to a space with large enough dimensions, try scaling the activity down to a tabletop version. For this version, you will need:

- A long table (more than 6 ft or 1.8 m) for testing. Cut the **Test Set-up** dimensions in half, i.e. the distances between the taped half circle and full circle are now 1.5 ft or .46 m.
- Use balls that are both small and have some weight, such as marbles or bouncy balls.

Be aware that this version of the activity may be more challenging for students than the full-scale version. Consider allocating extra time for teams to prototype.

Preparation

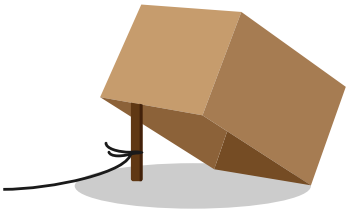
1. Collect, organize, and set up the building materials away from the testing area.
2. Print **Notes and Observations Handout** (one per team).
3. *Optional*: Cut three 1 ft or .91 m strings (one per team) so students can measure distance during prototyping.
4. Try out the activity yourself, with other educators or other learners you know. This will give you practice with the materials and tools and help you to anticipate student questions.
5. Plan to have students work in teams of 3-4.

Frame the Activity

Session One	60 min total
Frame the Challenge	**10 min total**
Activate Prior Knowledge	5 min
Introduce the Challenge	5 min
Design Challenge	**50 min total**
Prototype (Build and Test)	35 min
Share Solutions	10 min
Debrief	5 min

Activate Prior Knowledge *(5 min)*

1. Pass out the **Notes and Observations Handout**. Let students know that today they are going to be exploring how to activate devices from a distance.
2. Ask students to share some examples of devices that can be used without touching them? Examples might include devices that are activated by...
   - A remote control (e.g., TV or Blu-ray player)
   - Your voice (e.g., voice virtual assistants like Alexa or Siri)
   - Motion (e.g., paper towel dispensers or hand dryers in public restrooms)
3. Have students consider why some devices would need this feature.
   - e.g., safety reasons, adaptations for accessibility, etc.
4. Now ask students to consider other ways to activate a device that does not use electrical energy. **Guiding Questions** could include...
   - *Have you ever played with a wind-up toy? How did you make it work?*
   - *What kind of power do you think a slingshot uses?*
   - *What makes a marble move down a marble run?*
5. Let students know that today they are going to be exploring different ways they can use **potential energy** to build a device with a **trigger**.
   - Define a trigger as a built-in mechanism that releases stored energy.
   - Explain that the trigger allows your device to be ready, but also delays starting until it is activated.
6. Refer students to the **Potential Energy Examples** on **page 5** in the **Notes and Observations Handout**. Use the examples to introduce two forms of potential energy they will be working with today.

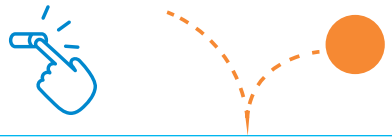
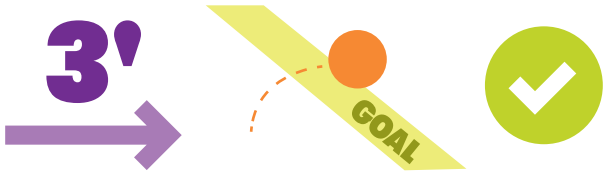
The stick-and-box trap uses **gravitational potential energy** by using the stick to prop the box. The string acts as the trigger. When it is pulled, gravity pulls the box to the ground.	
Wind-up toys like a toy car use **elastic potential energy** to move. When a key or knob is turned, it winds a coiled spring inside the toy. When the key is released, it releases the stored energy, causing the toy to move.	

Introduce the Challenge *(5 min)*

1. Introduce the **design scenario**:

> *Your soccer team needs to practice drills in rapid succession without being too close to the ball when it is released. No one wants to be hit or kicked accidentally! You need to design a device that can can both release the ball and be activated from a distance.*

2. Introduce the design problem, criteria, and constraints.

Design Problem	Design a device that releases the ball when activated by a trigger from a distance	
Criteria	• Trigger can be activated at least 3 ft (.91 m) away • Ball should reach the goal line solely by activating the trigger • Trigger should work the same way every time	
Constraints	• Use only the materials provided • There's a time limit	

3. Turn students' attention to the testing area.
   - Show students the taped circle, half circle, and line.
     - The circle is where they will place the ball and their device.
     - The person testing can stand anywhere on or behind the half circle to activate the device.
     - The ball must pass the line to meet the goal.
   - If applicable, show how to use the 3 ft long (approx. 1 m long) string to measure the distance between themselves and their device during prototyping.
     - This allows them to do initial tests from their own building area without coming to the formal test area.
4. Refer students to the **Ways to Activate Devices** examples on **page 6** in the **Notes and Observations Handout**. Let them know that this is just for inspiration to help them decide how they will build their trigger.

Design Challenge

Prototype (Build and Test) *(30 min)*

1. Divide students into teams of three to four. Let them know they will have about 30 minutes to build and test their initial design.
2. Encourage them to talk with their teammates for a few minutes about how they should build their device before collecting materials.

3. As they build, support teams by asking open-ended questions to guide the process:

Just Starting Out	• *How do you think you will build the device's trigger?* • *What item will be storing the potential energy?* • *Is your design inspired by any real-world devices?*
After Testing	• *How does your device transfer energy?* • *What kind of potential energy do you think it is using?*
Pushing Design Further	• *Does the trigger always work the same or is there possible variation between team members setting it off?* • *Can you design a trigger that sets itself off reliably?* • *Will you be able to reset the device the same way each time you test?*

4. Encourage them to collaborate with each other and use **pages 1** and **2** of the **Notes and Observations Handout** to take notes on their iterations.

Share Out *(10 min)*

1. At the end of the time limit, have teams stop even if they haven't been able to test yet.
2. Ask teams to pair up, ideally with a group that built a different kind of trigger than they did. Give them 5-7 minutes to demonstrate how their devices work with each other.
   - Have learners give each other positive feedback on their designs. Encourage them to tell the other team one thing they liked or noticed.

Debrief *(5 min)*

1. Bring the class back together when teams are done sharing or the time is up. Ask for volunteers to share something they liked or noticed about the other team's design.
2. Conclude the session by letting them know that they will be using their sketch from **Session 1: Activating Devices** to inform how they will proceed in the next session.
   - Ask any team that has not already done so to quickly sketch and label their device's design features in the space on **page 1**.
3. Collect the **Notes and Observations Handouts** and ask teams to take apart their devices.

Frame the Challenge

Session Two	60 min total
Frame the Challenge	**10 min total**
Activate Prior Knowledge	5 min
Introduce New Criteria	5 min
Design Challenge	**50 min total**
Prototype (Build and Test)	35 min
Share Solutions	10 min
Debrief	5 min

Activate Prior Knowledge *(5 min)*

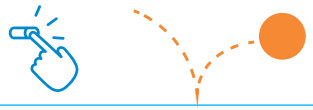
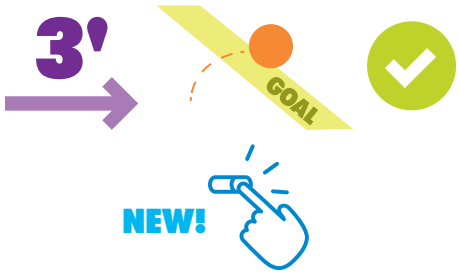
1. Have students return to their teams and pass back their **Notes and Observations Handouts**.
2. Ask **Guiding Questions** about the first session to refresh their memories. Remind them that they can look at their notes and sketch from the first session as a reference.
   - *How did your first trigger design work?*
   - *What worked well?*
   - *What were some challenges you encountered?*
   - *Were you inspired by any other team's designs?*
3. Ask students if they think this statement is true and false: "Once professional engineers find a solution that meets their criteria, they move to finalizing the product."
   - Correct answer: No! Engineers test out lots of possible solutions that could potentially meet the criteria to determine what will work best for their design.

Introduce New Criteria *(5 min)*

1. Let them know that in Session 2, they are going to be engaging in engineering best practices by prototyping a new trigger design for their device.
2. Ask teams to spend a few minutes before they start reviewing how they set up their device in Session 1 and how they may want to design their new trigger.
   - They may need to make changes to the original design of their device to accommodate the new trigger design.
   - During share out at the end of the session, they will need to identify what changes they made and what they kept the same from their original design.
3. Encourage them to think about how they could use a different kind of potential energy in their new trigger.
   - *For example:* If their first trigger used gravitational potential energy to work, have them think about how they could use elastic potential energy to activate their device.

Adaptation for Advanced Engineers

Consider making it a requirement for older or advanced engineers to use a different kind of potential energy in their new trigger.

Design Problem	Design a device that releases the ball when activated by a trigger from a distance	
Criteria	• Trigger can be activated at least 3 ft (.91 m) away • Ball should reach the goal line solely by activating the trigger • Trigger should work the same way every time • **New: Use what you've learned to design a new trigger**	
Constraints	• Use only the materials provided • There's a time limit	

Design Challenge

Prototype (Build and Test) *(35 min)*

1. Teams will build and test with the new criteria.
2. Support teams by asking open-ended questions:
   - *What is your new design for a trigger? What kind of potential energy does it use?*
   - *What information helped your team decide how to iterate on your design?*
   - *Did changing the way the energy is stored lead you to make other adjustments to your device?*
3. If students are having difficulty coming up with ideas, remind them they can look at the **Ways to Activate Devices** on **page 6** of the **Notes and Observations Handout** for inspiration.
4. Bring the class back together when the time is up.

Share Solutions *(10 min)*

1. Have teams take turns bringing their device to the testing area and demonstrating how it works.
2. Possible **Sharing Questions** include:
   - *Tell us how the trigger activates your device.*
   - *How did the trigger in the first part of the design challenge work?*
   - *Which trigger do you think worked better for your device and why?*
3. Have learners give each other positive feedback on their designs. Encourage them to tell the other team one thing they liked or noticed.

Debrief *(5 min)*

1. After students share their solutions, bring the conversation back to the engineering concepts and what they learned.
2. Lead a short debrief with some of these questions. Possible **Debrief Questions** include:

Design process

- *How challenging was it to switch from one kind of trigger to another?*
- *What are some elements that made the triggers successful?*
- *What was it like comparing two different triggers on one device?*

Science Concepts

- *How did the devices store and transfer energy?*
- *How does using stored energy help us better accomplish tasks?*
- *What kind of devices do you think use other kinds of potential energy, like electrical potential energy?*

Standards Connections

Next Generation Science Standards

Grades	Performance Expectation	Description
4	4-PS3-4	Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.
6-8	MS-PS3-5	Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.
9-12	HS-PS3-3	Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
Related Standards		HS-PS2-1
Science and Engineering Practices		Asking Questions and Defining Problems Planning and Carrying Out Investigations
Cross-Cutting Concepts		Patterns Cause and Effect

Vocabulary

- **Elastic potential energy:** The energy stored as a result of applying a force to deform an elastic object
- **Gravitational potential energy:** The energy an object possesses because of its position in a gravitational field
- **Potential energy:** The energy of position; energy that is stored and held in readiness — waiting to move (e.g., a ball held in the air, sitting still, waiting motionless)
- **Trigger:** A built-in mechanism that releases stored energy

On Your Mark, Get Set, Roll!
Notes & Observations Handout

Names: **Date:**

Session 1: Activating Devices

Use this space to take notes, sketch and reflect. See if you can label where energy is stored and how the trigger will activate the device.

Test 1

□ Trigger released the ball

□ Ball went past the goal line

What went well?

What needs adjustment?

Test 2	What went well?
□ Trigger released the ball □ Ball went past the goal line	What needs adjustment?

Test 3	What went well?
□ Trigger released the ball □ Ball went past the goal line	What needs adjustment?

Test 4	What went well?
□ Trigger released the ball □ Ball went past the goal line	What needs adjustment?

Names: **Date:**

Session 2: Designing a New Trigger

Use this space to take notes, sketch and reflect. See if you can label where energy is stored and how the trigger will activate the device.

Test 1

□ Trigger released the ball

□ Ball went past the goal line

What went well?

What needs adjustment?

Test 2	What went well?
□ Trigger released the ball □ Ball went past the goal line	What needs adjustment?

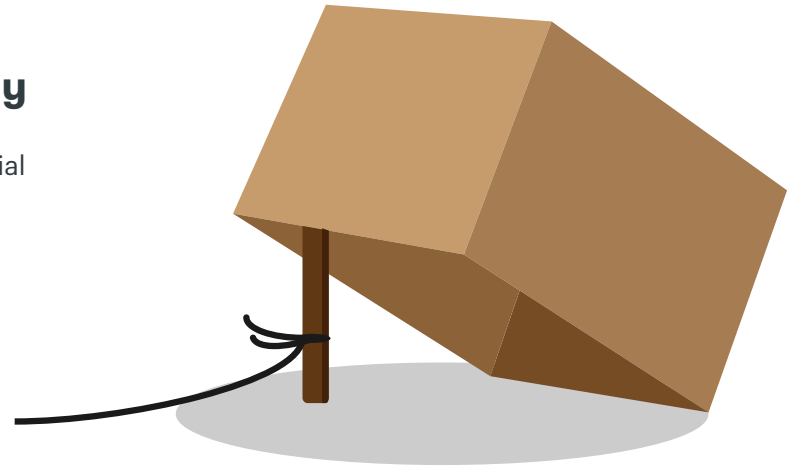
Test 3	What went well?
□ Trigger released the ball □ Ball went past the goal line	What needs adjustment?

Test 4	What went well?
□ Trigger released the ball □ Ball went past the goal line	What needs adjustment?

Gravitational Potential Energy

The stick-and-box trap uses gravitational potential energy by using the stick to prop the box.

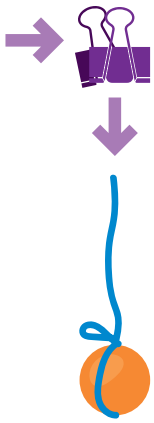
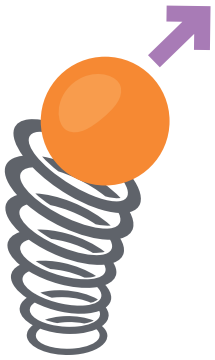
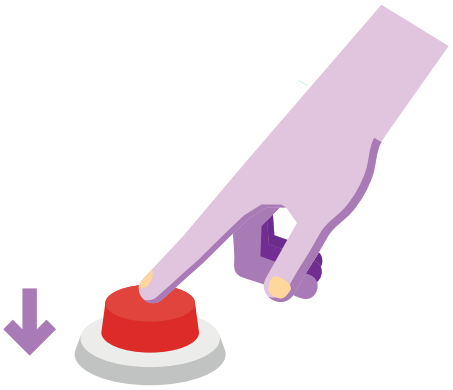
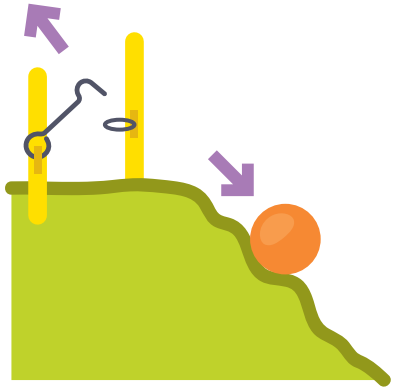
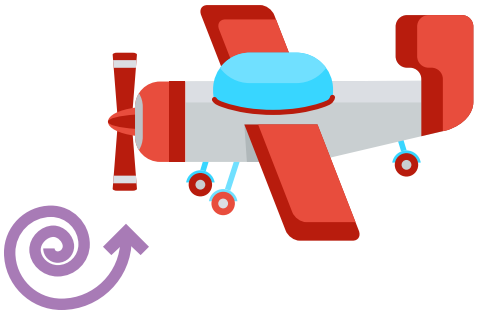
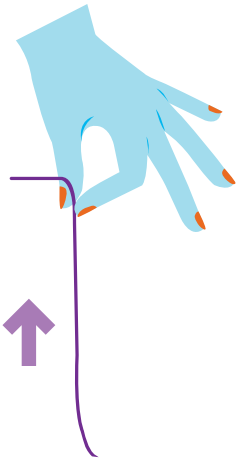
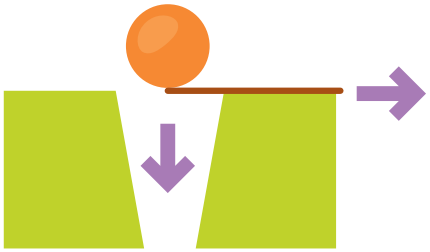
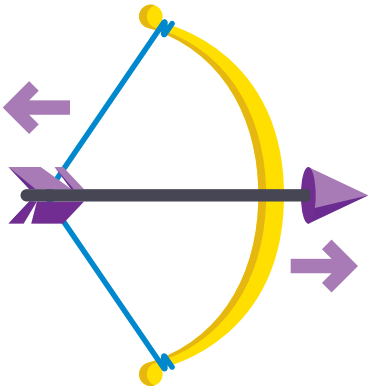
The string acts as the trigger. When it is pulled, gravity pulls the box to the ground.



Elastic Potential Energy

Wind up toys like the toy car uses elastic potential energy to move.

When a key or knob is turned, it winds a coiled spring inside the toy. When the key is released, it releases the stored energy, causing the toy to move.

Open a clip 	**Release a coiled spring** 	**Push a button** 
Lift a latch 	**Wind a rubber band** 	**Pull a string** 
Remove a stick 	**Stretch and release elastic** 	**What else can you think of?**