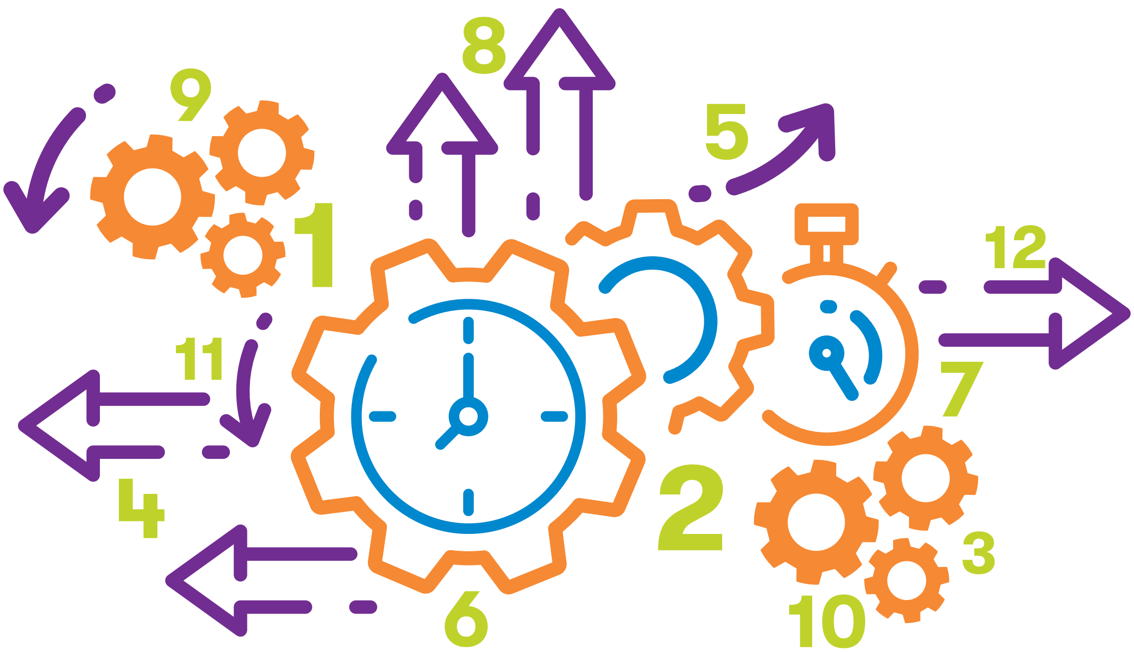
LESSON

Count the Seconds

The Tech Challenge 2022
Grade Levels: 4-8
Duration: 90 min

Students design a device that can track a specific amount of time and indicate when that time has passed with a sound or visual signal. They iterate their designs and prototypes to improve repeatability.



Outline

Frame the Challenge	15 min total
Define the Problem	10 min
Introduce the Challenge	5 min
Design Challenge Part 1	**30 min total**
Prototype (Build and Test)	20 min
Quick Share	10 min
Design Challenge Part 2	**45 min total**
Introduce New Criteria	5 min
Prototype (Build and Test)	20 min
Share Solutions	15 min
Debrief	5 min

Grade Levels: 4-8

Duration: 90 min

Concepts/Skills
Energy transfer, stored energy, simple machines, engineering, optimization, testing

Objectives
Students will:
- Design and build a device that indicates when a specific amount of time has passed.
- Use simple machines in their device.
- Identify the ways in which energy is stored and transferred in their device.
- Iterate and improve their designs based on testing and observation of failure points.

Materials and Preparation

Materials

(per class of ~32 students)					*(1 per group)*
Weights *(25+ total)*	**Rolling** *(10+ total)*	**Flexible** *(25+ total)*	**Structural** *(50+ total)*	**Connectors** *(100+ total)*	**Tools**
☐ Dice	☐ Beads	☐ Bags	☐ Binders	☐ Binder clips	☐ Hole punch
☐ Dominos	☐ Corks	☐ Cardstock	☐ Cardboard	☐ Paper clips	☐ Scissors
☐ Nuts and bolts	☐ Marbles	☐ Coffee filters	☐ Cardboard tubes	☐ Pipe cleaners (chenille stems)	☐ Stopwatch
☐ Rocks	☐ Small balls (ex: golf, ping pong)	☐ Fabric	☐ Craft sticks	☐ Rubber bands	
☐ Sand	☐ Spools	☐ Folders	☐ Food containers	☐ String	
		☐ Paper	☐ Poster board	☐ Tape	
			☐ Rulers		
			☐ Wooden skewers		

Tip: Don't use glue and limit the use of tape. This allows for faster iteration, more reuse of materials, and less mess.

Preparation

1. Collect, organize and set up materials.
   - Create materials kits for teams or set up materials at a central location where students can browse and choose the items of interest to them.
2. Print the **Student Handouts: Count the Seconds Challenge Parts 1 and 2** for each student. These tools can be used for data collection throughout the challenge.
3. Build a solution (or solutions) yourself, with other educators or kids you know. This will give you practice with the materials and tools in order to anticipate student questions.

The Tech Challenge

This lesson can be used to prepare students for the 2022 Tech Challenge: Kinetic Commotion, presented by Amazon.

This lesson will...

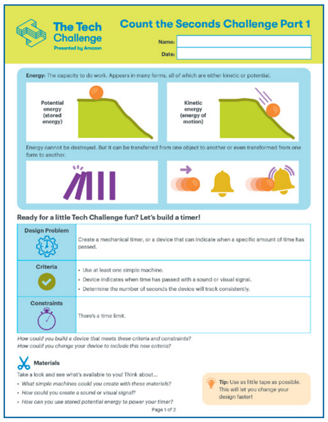
- Give students experience with building simple machines.
- Familiarize them with stored energy and energy transfer.
- Introduce students to triggers (release mechanisms).

The Tech Challenge
KINETIC COMMOTION
Presented by amazon
2022

Frame the Challenge

Define the Problem *(10 min)*

1. Ask students to think about what they know about tools that track and signal time. Ask them what manual or mechanical timers they might have seen before. Inquire:
   - *When do you have to set a timer? What do you use?*
   - *How would you keep track of time if you didn't have electricity?*
   - *How do devices signal or tell you that time has passed?*
2. Students may notice items around their home that do not use electricity to tell time (i.e., hourglasses or other timers in board games). They may also think of simple historical examples, like pendulums. (See **Real-world and Historical Examples** below for more inspiration.)
3. Explore with students what they might need to keep track of or signal time, i.e., something that moves, changes, or reduces to indicate when a time is up.
4. During this initial discussion, point out which examples mentioned by students use stored energy and energy transfer.
   - Review the definitions and examples of these concepts in the **Student Handout: Count the Seconds Challenge Part 1**.
   - Note that many of the historical examples start with **stored energy** (i.e., captured energy produced at one time for use at a later time.)
   - *For example:* When the weights in a grandfather clock are pulled to the top they have stored energy (**gravitational potential energy**) to power the clock and move the pendulum. Similarly, sand at the top of an hourglass and water held at the top of a water clock have gravitational potential energy and subsequently fall through the holes below. **Energy transfer** happens when the energy stored in the weights moves on to the pendulum, and then the hands of the clock.
   - Explain that storing energy is similar to storing other things in the real world. *For example:* If I store one liter of gasoline in my gas tank, my car can only run so far. Similarly, the amount of stored energy in their timers can vary depending on other factors. Let students know they will have a chance to experiment with stored energy throughout the design challenge.


The Tech Challenge
Presented by Amazon
Count the Seconds Challenge Part 1
Name:
Date:

Energy: The capacity to do work. Appears in many forms, all of which are either kinetic or potential.

Energy cannot be destroyed. But it can be transferred from one object to another or even transformed from one form to another.

Ready for a little Tech Challenge fun? Let's build a timer!

Design Problem	Create a mechanical timer, or a device that can indicate when a specific amount of time has passed.
Criteria	• Use at least one simple machine. • Device indicates when time has passed with a sound or visual signal. • Determine the number of seconds the device will track consistently.
Constraints	There's a time limit.

How could you build a device that meets these criteria and constraints?
How could you change your device to include this new criteria?

Materials
Take a look and see what's available to you! Think about...
- *What simple machines could you create with these materials?*
- *How could you create a sound or visual signal?*
- *How can you use stored potential energy to power your timer?*

Tip: Use as little tape as possible. This will let you change your design faster!

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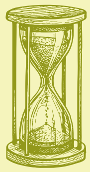
(Student Handout Pt 1, Pg 1)

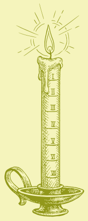
Real-world and Historical Examples

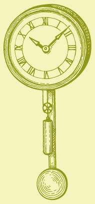
During your initial discussion students may mention some of these examples of real-world and historical timers and clocks.

- Shadow clocks and sundials
- Hourglasses
- Water clocks
- Candle clocks



- Pendulums
- Congreve rolling ball clocks
- Various gear-based mechanical clocks and watches





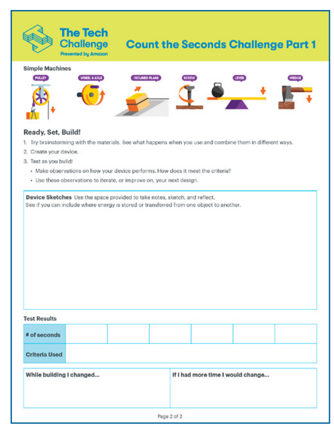
The images and background information of these real-world examples can serve as inspiration throughout the lesson.

Count the Seconds

Introduce the Challenge *(5 min)*

1. Introduce the design problem, criteria and constraints. Distribute the **Student Handout: Count the Seconds Challenge Part 1**.

Design Problem	Create a mechanical timer, or a device that can indicate when a specific amount of time has passed.
Criteria	• Use at least one simple machine. • Device indicates when time has passed with a sound or visual signal. • Determine the number of seconds the device will track consistently.
Constraints	There's a time limit.



(Student Handout Pt 1, Pg 2)

2. As you review the criteria, make sure students understand a variety of simple machines.
   - It may be useful to refer back to the examples from the initial discussion and point out how they used simple machines.
   - *For example:* An hourglass has an inclined plane, or the gears in many clocks are an example of wheels and axles.
3. In addition, review the concept of stored energy and how it can be used to power their timer. It may be useful to refer to some of the examples provided previously (i.e., sand in the top of an hourglass, weights in a grandfather clock).
4. Once students understand the criteria, clarify the design process and address any questions students have.
   - Students will test their devices by timing them with their stopwatch.
   - They do not need to determine the amount of time that their device will track until they start building. Instead of starting with a goal, they should develop one as they see how their prototype performs.
   - Longer periods of time might be more difficult for some of these early prototypes. It might be useful to let students know that their timers can track times of 10 seconds or less.
5. If you have not already done so, group students into teams of two to four.
6. It may be useful for teams to have some space to build (vertically as well as horizontally). Some ideas may involve going from a table to a floor or spreading out over a larger space.
7. ***Note:*** A 15-20 minute time limit is suggested for this first round of prototyping.

Design Challenge Part 1

Prototype (Build and Test) *(20 min)*

1. Set a stopwatch to track the time remaining.
   - Give students occasional reminders on time, criteria, and constraints to help them monitor their own progress.
2. During the prototyping time, walk around and support teams.
   - Help students focus on the process, rather than on the success of their designs. If their design fails, ask them how many things they have tried, what they notice about what isn't working, and what they might try next.
3. Ask open-ended questions to encourage students to reflect on their process.

Prototype Questions

Just Starting Out
- *What simple machines could you create with these materials?*
- *How could you create a sound or visual signal with these materials?*
- *How can you use stored **potential energy** or **kinetic energy** to your advantage as you build?*

After Testing
- *How does your design meet the criteria?*
- *Where are the failure point(s) of your device? What are the places it doesn't work as intended? What caused the failure?*
  - *How could you alter that part of the device?*
- *What can you add or adjust to make the timekeeping part of your device more consistent?*
- *Where does the energy in your design come from? How is energy transferred from the beginning to end?*
- *How does modifying the amount of stored energy in your device affect the time it is tracking?*

Pushing Design Further
- *Is there a different way to solve this problem?*
- *How could you use simple machines differently in your device?*
- *How can you alter the amount of stored energy to alter the timing of your device*

4. Encourage teams to test while they build.
5. Encourage them to collaborate with each other and use the **Student Handout: Count the Seconds Challenge Part 1** to take notes on their iterations.

Quick Share *(10 min)*

1. At the end of the time limit, teams stop even if they haven't been able to build or complete something.
2. This pause in the prototyping is an opportunity for teams to share their progress with each other and to be inspired by the approaches other teams are taking.
3. This sharing is designed to be quick so teams can focus on how their device is intended to work and the next steps they plan to take.
   - Have all of the teams stand up in a large circle. Give each team 30 seconds to demonstrate and share the highlights of their device, including how their devices store and transfer energy.
4. Encourage students to give each other positive feedback on their designs by telling the other teams one thing they liked or noticed.
   - Teams can mention how others' ideas are inspiring them to add to their own designs.

Collaboration

Collaboration is critical to engineering a successful solution. Encourage teams to reflect on how they are collaborating within their own team as well as with the larger class.

After the Quick Share, some students may be inspired to borrow ideas from another team. Remind them that this is a common practice in engineering as long as they "copy with credit." *For example:* "After seeing how the Green team was using weights to balance their pulley, we added some marbles as a counterweight. Thanks Green team for the idea!"

See the **Innovator Mindsets Tech Tip** (PDF and Video) for more ideas on how to support collaboration and other critical mindsets during a design challenge.

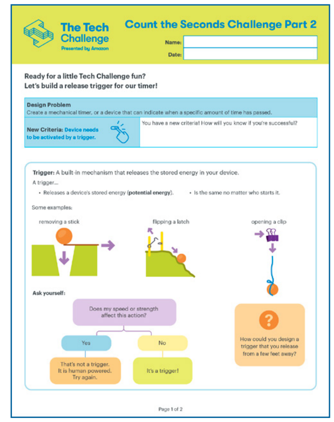
Design Challenge Part 2

Introduce New Criteria *(5 min)*

1. Let students know that you will be introducing a new criteria based on real-world constraints.
   - Most clocks and timers need to be able to be set as well as operate without a human to continually power them. So, students will need to include a trigger that releases the stored energy and starts their device.
2. Review the previous criteria and introduce the new criteria. Distribute the **Student Handout: Count the Seconds Challenge Part 2**.

Design Problem	Create a mechanical timer, or a device that can indicate when a specific amount of time has passed.
Criteria	• Use at least one simple machine. • Device indicates when time has passed with a sound or visual signal. • Determine the number of seconds the device will track consistently. **NEW** • **Device needs to be activated by a trigger.**
Constraints	There's a time limit.

3. As part of the previous criteria, teams should have determined the amount of time they want their timer to track. Consistency can be measured by trying to achieve this goal three times in a row.
4. Once they have met the initial criteria they can add in the new criteria of activating their device with a trigger.
    - Review the concept of triggers with students. (See the information included in **Student Handout: Count the Seconds Challenge Part 2** for some examples.)
    - Remind them that:
        - A trigger is a release mechanism that starts your device.
        - Triggers are used to release the stored energy in your system.
        - A trigger allows your device to be ready, but also to delay starting until it is activated. (Pulling away the block that keeps a ball from rolling down a ramp.)
    - Have a few teams share what source of stored energy they have in their devices and where energy is transferred in their system. Ask teams to begin thinking about how they might use a trigger to initiate the release of the stored energy.


The Tech Challenge
Presented by Amazon
Count the Seconds Challenge Part 2
Name:
Date:

Ready for a little Tech Challenge fun?
Let's build a release trigger for our timer!

Design Problem
Create a mechanical timer, or a device that can indicate when a specific amount of time has passed.

New Criteria: Device needs to be activated by a trigger.
You have a new criteria! How will you know if you're successful?

Trigger: A built-in mechanism that releases the stored energy in your device.
A trigger...
- Releases a device's stored energy (**potential energy**).
- Is the same no matter who starts it.

Some examples:

Ask yourself:

Page 1 of 2

(Student Handout Pt 2, Pg 1)

Prototype (Build and Test) *(15 min)*

1. Iteration is an important part of the design process. Provide students time to revisit and revise their devices and triggers based on their testing, feedback, and observations of other team's designs.
2. Once again, teams should use this time to build, test, and reflect.
3. Teams that have met the initial criteria should add in the new criteria just introduced.
4. During the prototyping time, walk around and support the teams.
5. Use open-ended questions to encourage students to focus on the process:

Prototype Questions

- *Where does the energy in your design come from? How is energy transferred from the beginning to end?*
- *What ways can you release that energy to start your device?*
- *What ideas do you have about meeting the new criteria? Where can you get more ideas?*

Perseverance

As teams work on improving the reliability of their devices they may find the process challenging and frustrating. Remind them that failure and learning from these experiences is a large part of the process. Persevering through these setbacks and examining the failure points of their device carefully will improve their ability to meet the criteria.

Short design challenges encourage teams to focus on the process and iterate quickly. Some teams might not build successful devices and very few teams will build something perfect. That's ok because everyone can take what they've learned and apply it to other situations!

Share Solutions *(15 min)*

1. At the end of the time limit, teams stop even if they haven't been able to complete their design.
2. Have each team take turns demonstrating their device and sharing their process.
3. Keep the sharing simple and focused on what they did and why.
4. Possible **Sharing Questions** include:
   - *Tell us how your design works (including how your device stores and transfers energy).*
   - *What did you adjust/change as you built?*
   - *What would you change if you had more time?*
5. Have students give each other positive feedback on their designs. Encourage them to tell the other teams 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.
3. Possible **Debrief Questions** include:

   Design Process
   - *What did you notice about the different prototypes (similarities and differences)?*
   - *What did you notice about the process to improve the reliability of your device?*

   Science Concepts
   - *Where did you notice simple machines used in the devices?*
   - *When did the devices have potential energy and when did they have kinetic energy?*
   - *How did the devices store and transfer energy? What did you notice and wonder about how energy transferred from one object to another?*
   - *How did the use of a trigger change the devices?*

Adaptations for Distance Learning

- **Introduction:** Frame the challenge to students in a live video session. Model materials gathering with a **Materials Treasure Hunt**.
- **Prototyping and Testing:** Have students use materials from around their home to design the device asynchronously.
- **Sharing:** Have students collect and share their results using an online tool (shared slide deck, Flipgrid, Padlet, etc.). Schedule a live video session, if possible, for students to share solutions, give feedback, and debrief.
- **Design Challenge Part 2:** Introduce the new criteria in a live video session. Students can then asynchronously revise and improve on their designs.

For more adaptations see our **Educator Tips for Remote STEM Learning**.

Standards Connections

Next Generation Science Standards

Grade	Standard		Description
4	**Performance Expectation**	4-PS3-4	Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.
6-8	**Performance Expectation**	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	**Performance Expectation**	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		3-5-ETS, 4- PS3-3, MS-ETS1-4., MS-PS3-5, HS-ETS1	

Vocabulary

For more tips on vocabulary and common engineering terms see our **Tech Tip: The Language of Engineering**.

- **Energy:** The capacity to do work; appears in many forms, all of which are either kinetic or potential.
- **Stored energy:** Captured energy produced at one time for use at a later time.
- **Energy transfer:** The conversion of one form of energy into another, or the movement of energy from one place to another.
- **Failure point:** A place where the design or system failed.
- **Gravitational potential energy:** Potential energy created by increasing height.
- **Kinetic energy:** Energy of motion, includes heat, sound, and light (motion of molecules)
- **Optimal design:** The design or device that best meets the criteria and constraints.
- **Optimization:** The process of iterating, refining and making trade-offs until a solution is found that best meets the criteria within given constraints.
- **Potential energy:** Energy that is stored and held in readiness; energy of position (gravitational or elastic potential energy); or chemical potential energy (e.g., fossil fuels, electric batteries, and food consumed).
- **Trade-off:** A situation in which you must choose between or balance two things that are opposite or cannot be had at the same time.
- **Trigger:** A built-in mechanism that releases the stored energy in a device.

Student Handouts

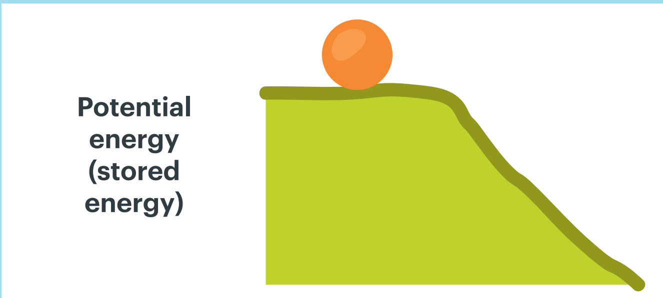
Count the Seconds Challenge Part 1

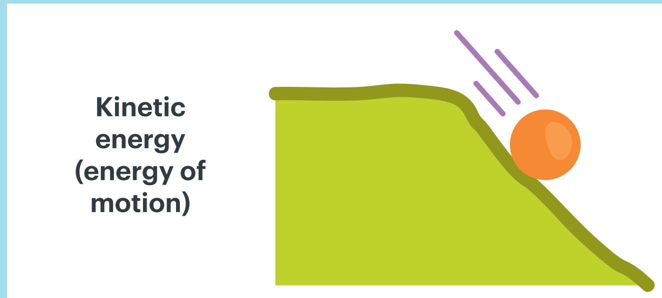
The Tech Challenge
Presented by Amazon

Name:

Date:

Energy: The capacity to do work. Appears in many forms, all of which are either kinetic or potential.





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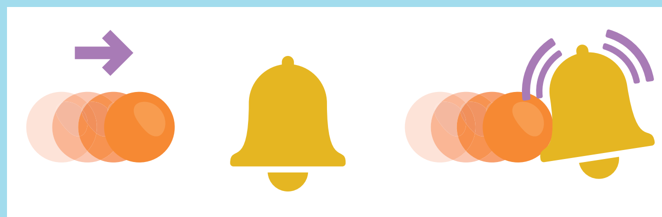


Ready for a little Tech Challenge fun? Let's build a timer!

Design Problem	Create a mechanical timer, or a device that can indicate when a specific amount of time has passed.
Criteria	• Use at least one simple machine. • Device indicates when time has passed with a sound or visual signal. • Determine the number of seconds the device will track consistently.
Constraints	There's a time limit.

How could you build a device that meets these criteria and constraints?
How could you change your device to include this new criteria?

Materials

Take a look and see what's available to you! Think about...

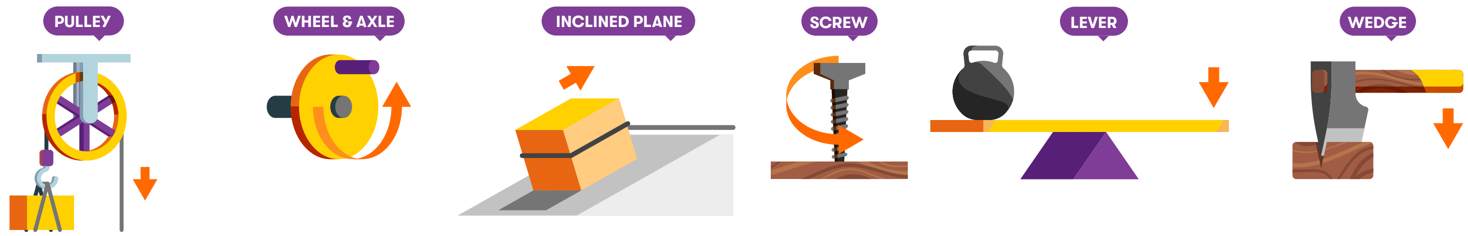
- *What simple machines could you create with these materials?*
- *How could you create a sound or visual signal?*
- *How can you use stored potential energy to power your timer?*

Tip: Use as little tape as possible. This will let you change your design faster!

The Tech Challenge
Presented by Amazon

Count the Seconds Challenge Part 1

Simple Machines



Ready, Set, Build!

1. Try brainstorming with the materials. See what happens when you use and combine them in different ways.
2. Create your device.
3. Test as you build!
   - Make observations on how your device performs. How does it meet the criteria?
   - Use these observations to iterate, or improve on, your next design.

Device Sketches Use the space provided to take notes, sketch, and reflect.
See if you can include where energy is stored or transferred from one object to another.

Test Results

# of seconds						
Criteria Used						

While building I changed...	**If I had more time I would change...**

Count the Seconds Challenge Part 2

The Tech Challenge
Presented by Amazon

Name:

Date:

Ready for a little Tech Challenge fun?
Let's build a release trigger for our timer!

Design Problem
Create a mechanical timer, or a device that can indicate when a specific amount of time has passed.

New Criteria: Device needs to be activated by a trigger.

You have a new criteria! How will you know if you're successful?

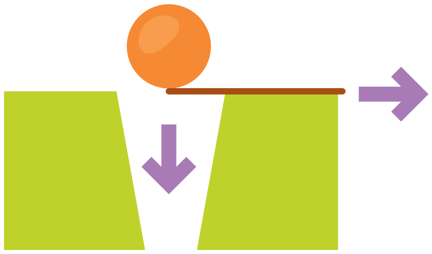
Trigger: A built-in mechanism that releases the stored energy in your device.

A trigger...

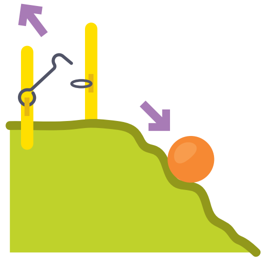
- Releases a device's stored energy (**potential energy**).
- Is the same no matter who starts it.

Some examples:

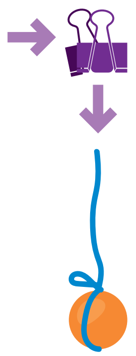
removing a stick



flipping a latch



opening a clip



Ask yourself:

Does my speed or strength affect this action?

- Yes → That's not a trigger. It is human powered. Try again.
- No → It's a trigger!

How could you design a trigger that you release from a few feet away?

The Tech Challenge
Presented by Amazon

Count the Seconds Challenge Part 2

Ready, Set, Build!

1. Reflect: Did you meet the previous criteria? Do you need to adjust anything before designing your trigger?
2. Create the trigger for your device.
3. Keep testing as you build!
   - Make observations on how your device performs. How does it meet the criteria?
   - Use these observations to iterate, or improve on, your next design!

Device Sketches Use the space provided to take notes, sketch, and reflect.
See if you can include where energy is stored or transferred from one object to another.

Test Results

# of seconds						
Observations						

While building I changed...	**If I had more time I would change...**