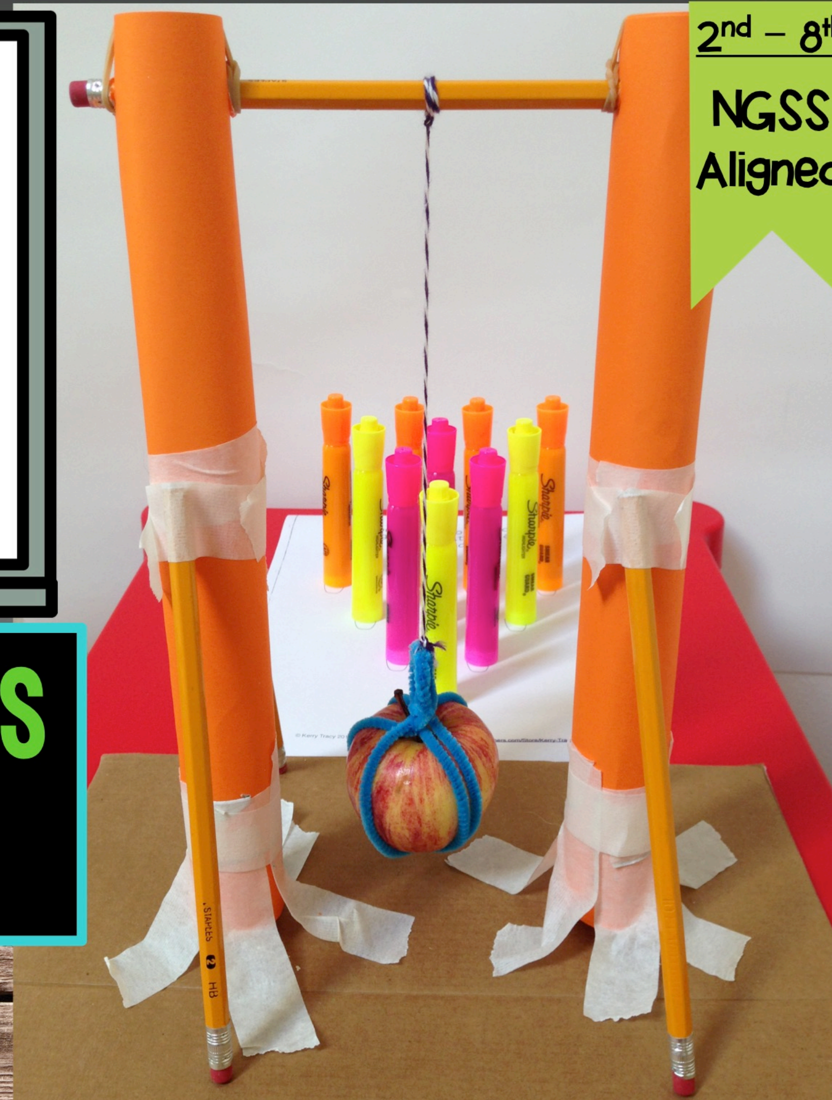
BTS STEM CHALLENGE
APPLE ANNIHILATOR

DIGITAL/PAPERLESS VERSION



2nd – 8th

NGSS Aligned

FOR USE WITH GOOGLE SLIDES

Perfect for force & motion standards

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I look forward to your feedback. If you have questions or suggestions, please do not hesitate to contact me through any or all of the links below:

Thanks & happy teaching!
~ Kerry

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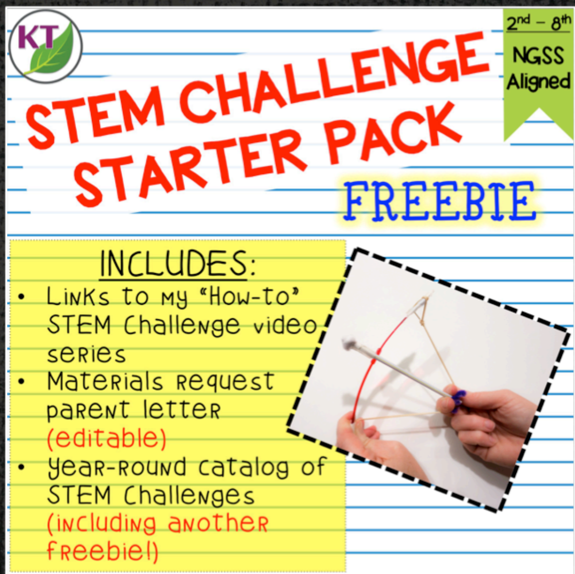
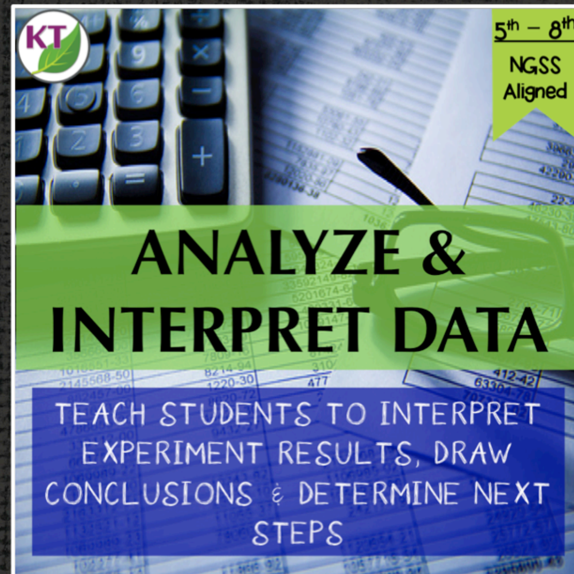
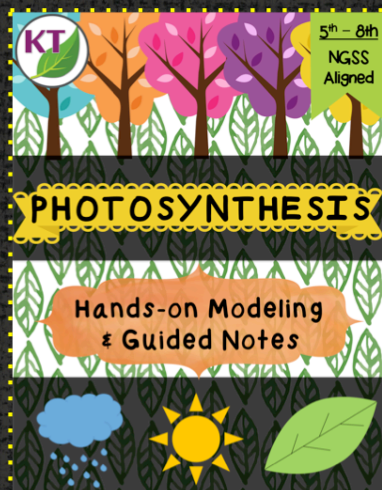
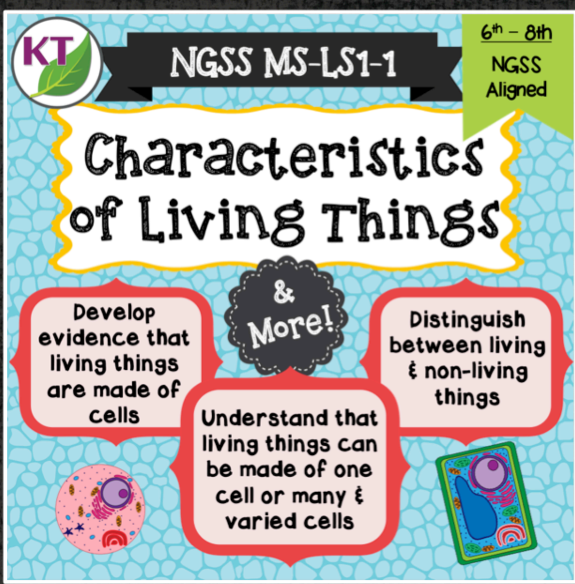
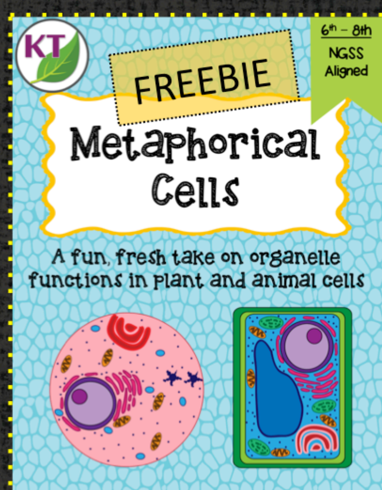
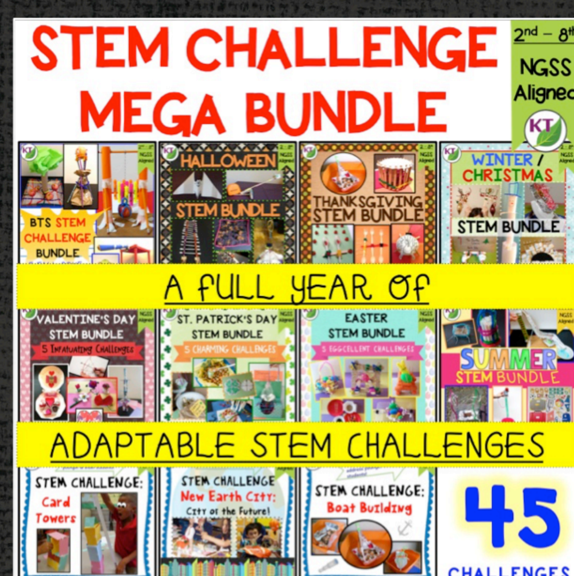






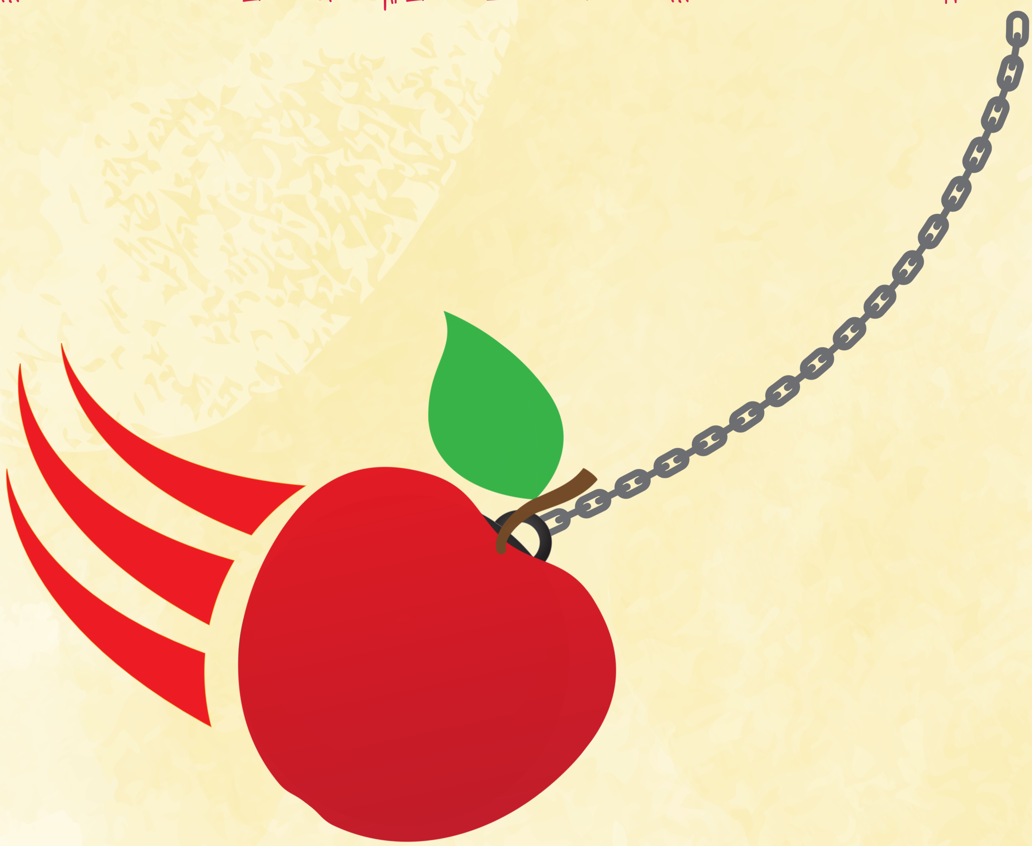






BACK-TO-SCHOOL STEM CHALLENGE:

APPLE ANNIHILATOR



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Click on any entry below to navigate through the document.

CLICK HERE TO GO STRAIGHT TO THE MASTER FILE IN GOOGLE SLIDES.

GETTING STARTED

1. Your students will need their own Google accounts to access the file in Google slides. If you need help setting up Google Classroom, search for how-to videos on YouTube. I found this one helpful, but there are plenty to choose from!

2. Review the Teacher Tips for this challenge in the following pages.

3. Create a copy of the master Google Slides file. Rename this file "Teacher" or "Master" copy. There is a video on slide 1 that provides a quick explanation of the file contents/layout.

4. Create a second copy of the file for your students. This way, you always have a master copy with all the slides available. In the student file, delete any pages you don't wish to have students complete, or consider breaking the large file into smaller chunks (Day 1, Day 2, etc.) prior to sharing the file with your class.

Apple Annihilator Materials

Select from the list. Materials can be purchased at you local dollar store or Target/Wal-Mart, etc. Make sure students have an equal amount of each material provided.

- **For each student or group:**
  - Set of markers (10)
    - Markers will be used like bowling pins, so must stand on their own. Crayola or broad highlighters work well.
  - Apple (1)
  - Pocket folder with prongs (1)
    - File folder or pocket folder without prongs may be substituted
  - Small or medium binder clips (1 – 2)
  - Unsharpened pencils (4 – 6)
  - Tape (24 – 36 in.)
  - String or yarn (36 – 48 in.)
  - Ruler
  - Scissors
  - Design analysis slides
  - Marker "bowling pin" handouts (included)
  - **Optional**
    - Cardboard boxes, tubes, or scraps (helpful in building a support structure and base for the wrecking ball rather than attaching to desk/table)
    - Craft sticks
    - Pipe cleaners
    - Dowels
    - Rubber bands

Video Walk-Through

The image below is linked to a video walk-through of the challenge. For more Back-to-School STEM challenges, check out the Back-to-School video playlist.

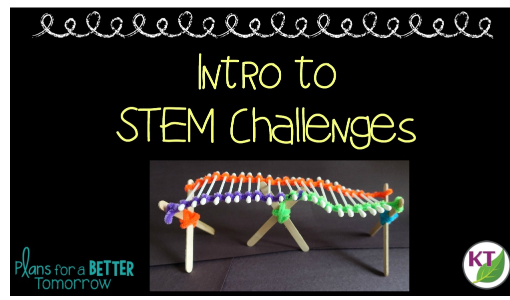
Note to Teachers

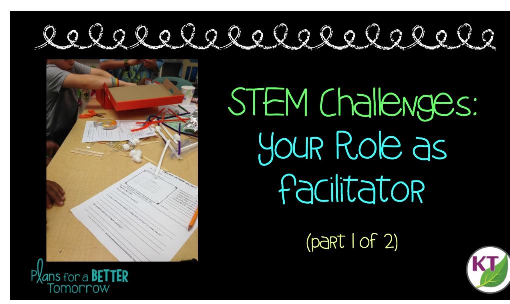
The beauty of STEM Challenges is that they are open-ended and require critical thinking and problem-solving. This is why we don't give students directions to build a specific design. In keeping with the engineering design process, a criteria & constraints list is provided to give students a framework of the design problem and goal. How they choose to address the problem and goal is entirely up to them.

You can tailor the challenge to your students' needs using the editable list provided, but don't make it too easy! Be bold and embrace the *challenge* – it's in the title after all! Understand that the potential to fail is an inherent risk, and in fact, when you're prepared for that possibility, a "failure" can turn into a far richer lesson than a success. Check out the first video linked below for more on what you can do to prepare for – and even look forward to – a potential "fail"!

Videos & PD

Video is such an effective way to share tips and examples for running fantastic STEM Challenges! I've linked a few below to help get you started and cover some troubleshooting topics as well.





You can also find my full video library & newest PD on:

YouTube

Facebook

If you have any questions, please feel free to reach out via email or social media!

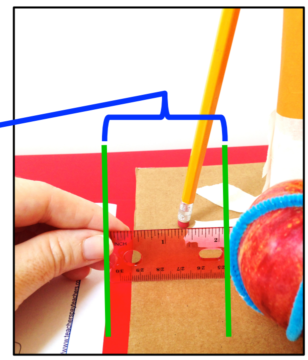
- **Premise**
  - In partners/groups, students will design and build an apple wrecking ball to annihilate a set of markers!
    - Students will set up marker "bowling pins" and try to knock down as many as possible using their apple wrecking ball designs.
  - Plan to give students approximately 40 min. to design, 10 – 15 min. to measure and share results, and 10 – 15 to complete design analysis slides. Additional time will be needed if you are assigning extension activities.
    - Note: If you are new to STEM challenges, you may wish to schedule 90 minutes so you have ample time for discussion and analysis.

- **Set up**
  - Watch the challenge walk through video. If you are new to STEM Challenges, you may also want to view one or more of the videos on the previous page.
  - Students can either build on the floor, desks, or, for more flexibility, you may want to provide a cardboard base as a foundation (see cover photo).
  - If you have purchased this challenge as part of the 5-in-1 bundle (or if you separately purchased "Apples Aloft"), you may wish to use the wrecking ball designs created here to knock down the towers created in Apples Aloft. If you decide to do that, you will either need to require the towers or wrecking balls be portable or storable (depending on which challenge is conducted first), or you will need to conduct the two challenges back-to-back.
  - Review the Criteria & Constraints List provided and decide if you will make any modifications ahead of time.

- **Criteria/Constraints**
  - The Criteria & Constraints List slide provided is editable.
  - Increase or decrease the time as needed.
  - For younger students, you might want to provide extra tape and/or allow them to use one hand to support/steady the wrecking ball design when testing (constraint listed doesn't allow them to touch any part other than the apple).
  - Ideas to increase the difficulty of the challenge:
    - Add a criterion that the entire design must be portable.
    - Add a constraint that the design may not be taped down to the desk/floor.
    - Increase the required distance between the wrecking ball and pins handout.
    - Add a criterion to test for accuracy (In addition to total annihilation).
      - Set up 3 pins (two versions of this handout are provided). Have students aim to knock down only one pin. You can either direct them which one(s) or allow them to choose.

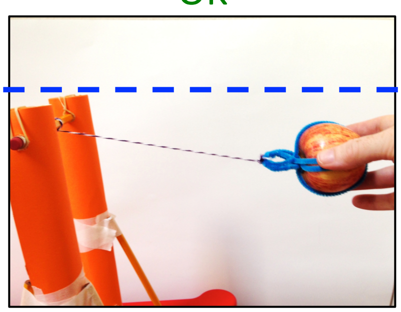
- **Measuring Results**
  - Students should verify they have met all listed criteria/constraints.
  - The design analysis slides provide two options for measuring results: Annihilation & Accuracy
    - If students are not conducting both tests, simply have them type “NA” for the test they will not conduct.
    - Three optional, printable bowling pin handouts are provided to serve as a student guide for setting up their markers. While it isn’t necessary to print these guides, it does tend to speed up the testing process. Alternatively, there are student direction slides provided in the Google file.
  - Students will set up the marker bowling pins at least 2 inches from the hanging apple.

Measure at least two inches from the edge of the hanging apple to the bottom edge of the bowling pin handout.

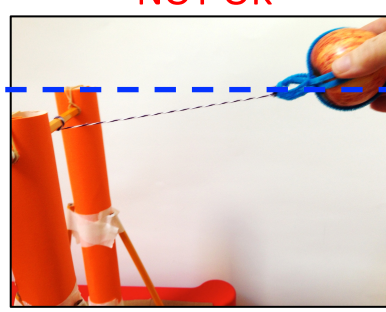


  - Students will release the wrecking ball from an angle of their choosing, however, the release point may not be higher than the tallest point in their design. See below.

OK



NOT OK



  - On the design analysis slides, students will note how many pins were knocked down out of the total (e.g. 7/10). Allow each student in the group to set up and release at least once. Direct students to record either the best score or average team score.
  - If you added an accuracy criterion, students can use either of the 3-pin handouts to test. Have students aim for just one pin for four separate releases and record their success rate on the design analysis slides as a percentage or fraction. A successful release is hitting *only* the intended pin.
    - Example: Release 1, two pins were hit (fail). Release 2, one pin was hit, but not the one intended (fail). Releases 3 and 4 successfully hit intended pins. Accuracy = 2/4 or 50%.

- **Post-Design Options**
  - Design analysis & discussion questions
  - Re-design and re-test (consider incorporating new, student-suggested materials)
  - Extension activities
    - This challenge is a natural engagement activity for NGSS standards on forces & interactions (3rd grade: 3-PS2-1, 5th grade: 5-PS2-1, Middle School: MS-PS2-1 and PS2-2). Watch these video clips to introduce Newton's Laws of Motion. *(Note: If you also own the Apple Ally challenge, beyond the first video, this is a unique list.)*
      - Newton's Laws of Motion ~ 4 min. (3rd – 8th)
      - Newton's Laws Song ~ 2 min. (3rd – 6th)
      - Newton's Laws Song 2 ~ 4 min. (4th – 8th)
      - Newton's Laws of Motion & Forces ~ 12 min. (5th – 8th)
      - Newton's Laws Rap ~ 3 min. (6th – 8th)
        - » Note: This is a satirical take on rap videos. At 2:13, there is a brief close up where the rapper grabs himself, so you may find this video inappropriate for your students.
      - Newton's Laws of Motion (advanced) ~ 11 min. (8th +)
      - Newton's First Law: Mass & Inertia ~ 6 min. (8th+)
      - Newton's Second Law: F=ma ~ 4 min. (8th+)
      - Newton's Third Law: Action & Reaction ~ 5 min. (8th+)
      - Epic Rap Battles: Isaac Newton vs. Bill Nye ~ 3 min. (8th+)
        - » Note: This is a satirical take on rap videos. Watch before showing your students as you may find some content inappropriate.
    - Wrecking Ball / Newton's Cradle / Conservation of Energy Videos
      - Wrecking Ball Video ~1 min. (2nd – 8th)
      - Wrecking Ball Demo/Conservation of Energy ~ 2 min. (3rd – 5th)
      - High-speed Newton's Cradle ~ 2 min. (3rd – 8th)
      - Mythbusters Season 11, episode 2 ~ 50 min. (5th – 8th)
        - » If you don't have Hulu or Netflix DVD, short excerpt clips are available on YouTube, and you can also purchase the full episode on YouTube.
      - Conservation of Energy: Free Fall, Springs, & Pendulums ~ 5 min. (8th+)

Note: One slide per video is included in the student slides with its link, so you can easily assign to students.

- **Post-Design Options**
  - Extension activities (continued)
    - Ask students how Newton's Laws of Motion can be applied to what they see happening in this challenge. This could be quite challenging for students! Urge them to uncover what is confusing them and what they need to research to clarify their understanding. Then be sure to give them time to conduct inquiry/ research and share their findings.
      - » Example: When the apple hits the markers, the apple and markers apply equal forces upon each other in opposite directions (Newton's 3rd law).
        - Although the forces applied are equal and opposite, the markers appear to have a bigger reaction. The markers' force applied to the apple didn't seem to change its course at all, while the apple's force applied to the markers sends the markers flying. Why?
          - This is due to the second law: F=MA. The forces applied to the apple and marker are equal, but their masses are different. The apple's greater mass makes its acceleration in the opposite direction negligible, while the markers' smaller mass causes them to accelerate more noticeably.
      - » *Teacher Tip: Don't be afraid to admit you don't know the answers to student questions, if you don't. Don't panic! View it as an opportunity to model the inquiry and problem-solving process by thinking aloud. State what you do understand, what you wonder or what is unclear, and what you would do to find out. Consider using a concept/question bulletin board or document to track class progress.*
        - *When we react to not knowing with fear, disinterest, or avoidance, we teach students they should be embarrassed when they don't know something and try to hide it. Always take the chance to show yourself as an imperfect, lifelong learner with a growth mindset and an abundance of curiosity.*
    - Conduct a series of pendulum experiments to determine how changes to weight, angle of release, and string length impact the number of oscillations.
      - If you teach 5th – 8th, you might find this Analyze & Interpret Data Unit helpful here.

- **Post-Design Options**
  - Extension activities (continued)
    - Close read one or more articles.
      - Wrecking Balls. (The article returned a Flesch-Kincaid reading grade level of 10.2, but I would be comfortable using it with 7th and 8th graders who are reading on grade-level.) When they are finished, have students create a pros and cons list for the use of wrecking balls in construction.
        - » Note: Be aware that there is a line that wrecking balls make "a hell of a mess" in the paragraph under the close-up photo of a wrecking ball and brick wall, so you might desire to edit before copying.
      - Newton's Cradle. The article returned a Flesch-Kincaid reading grade level of 11.9, but this seems wildly inflated. I would be comfortable using it with 5th – 8th graders who are reading on grade-level.
      - Wrecking Ball Physics The article returned a Flesch-Kincaid reading grade level of 9.4
      - Motion, Forces, and Energy (This is more of an intro/study guide)
    - Give students three minutes in groups to generate a list of as many uses for a wrecking ball as possible (the stranger, the better).
    - Give students three minutes in groups to generate as many synonyms for annihilate as possible. Repeat with antonyms. Add these to word walls or writer's notebooks. If time, identify the part of speech for each word.
      - Have students select at least 4 words from each list and assign monetary values up to $1.00 to the words based on how weak or strong it is. Example: knock down $0.05, destroy = $0.10, topple = $0.25, annihilate = $1.00).
      - Have students write sentences or a paragraph using some of their high-value words.
    - If you also own "Apples Aloft", use the Apple Annihilator to destroy the towers. The goal should be to annihilate the towers using the fewest number of wrecking ball releases.
    - Students create a process flow map for how to make their Apple Annihilator designs. They trade process maps and try to build the other's design (process flow map slide included).
    - Students create and solve math problems related to designs (slides included)).

Note: One slide per article is included in the student slides with its link, so you can easily assign to students.

Universal STEM Challenge Notes & How to Use the Design Analysis Slides

STEM Challenge Cycle (overview video of the STEM Challenge steps)

Planning

- Try giving students experience with different planning styles on different challenges, so they can begin to understand their own preferences. Several approaches are listed below:
  - Students begin to manipulate materials immediately
  - Students sketch ideas prior to building
  - Students discuss ideas with teammates prior to building
  - Have students jot notes for their plan prior to building
  - Students have 3 – 5 minutes of silence to think about what they will do prior to building (follow with another approach, or go straight into building)
  - Walk & talk: Introduce the challenge, then have students go on a short walk to discuss ideas with teammates prior to building
  - Free choice or mix/combine approaches

Post-Design – Design Analysis Slides

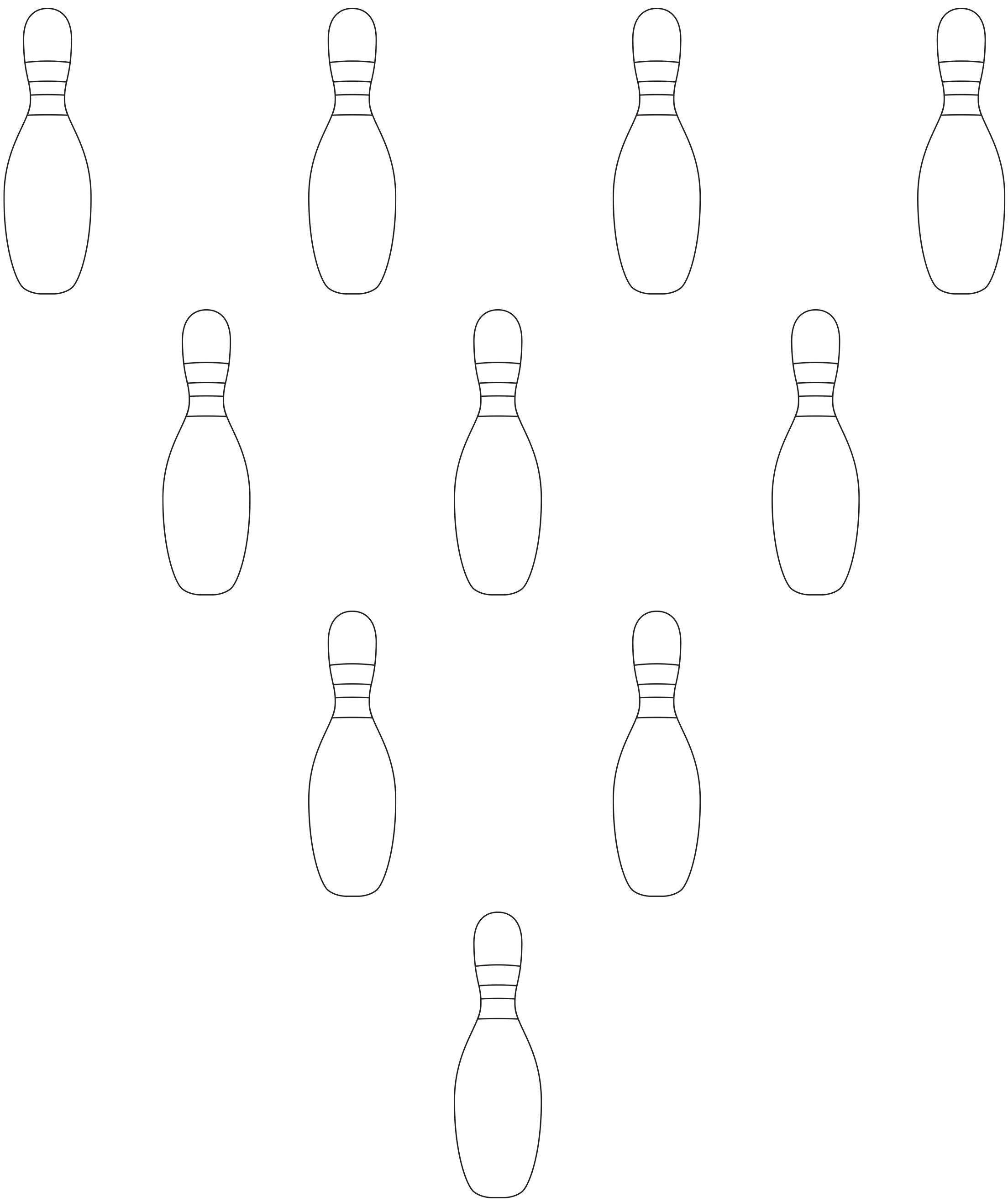
- Multiple iterations are always recommended to allow students an opportunity to apply learning, try new ideas, and to be in keeping with the engineering process. While you might not be able to do so with every challenge, try to do it whenever you can. Never conducting a second or third iteration is akin to never asking students to tell you how they *could* improve their writing, but never actually having them revise it; the execution of ideas is crucial in developing skills!
  - For each new iteration, make a new copy of the design analysis slides.
  - The following analysis question can be used in different ways: "Which was your more/most effective design? What do you think it was about the design that made it superior to the other(s)?":
    - **Option 1:** Have students consider the evolution of their design within the current iteration of the challenge. Frequently, students change aspects of the design right up until time is called. Their final version is not necessarily the best version. If they insist they stuck with one idea throughout and have nothing to compare, select option 2 or 3 below.
    - **Option 2:** Students can select what they think was the most effective design in the class, not necessarily their own.
    - **Option 3:** If you will conduct multiple iterations, students can wait to answer this question until after the final iteration, and answer it only once on the final set of handouts (or use options 1 or 2 to answer the question prior to the last handout set).

Grades
2 - 8

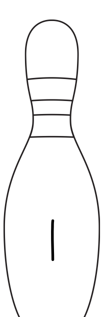
PRINTABLE MARKER SET-UP GUIDE

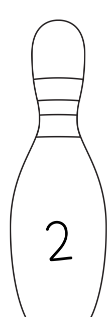
(OPTIONAL)

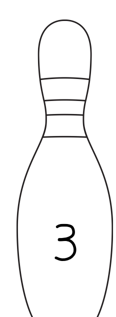
Set up one marker on top of each bowling pin to test your Apple Annihilator.



Set up one marker on top of each bowling pin to test your Apple Annihilator for accuracy. Your teacher will tell you the number of the pin you must knock down while leaving the other two standing.







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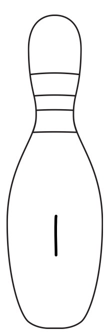

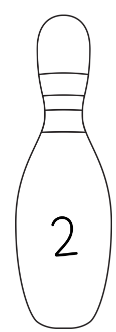

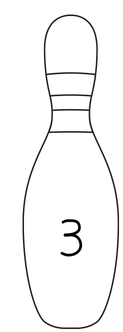

Next Generation Science Standards (NGSS)

A Note RE: NGSS Science & Engineering Practices

This STEM Challenge has the potential to hit upon all NGSS ETS standards depending on the depth and number of iterations you choose to implement in your classroom. Take a moment to review the Performance Expectations as well as the Disciplinary Core Ideas (DCIs) included here prior to inform your decisions and approach.

K-2 NGSS
Science & Engineering Practices: Performance Expectations

K-2 Science & Engineering Practices

Students who demonstrate understanding can:

- **K-2-ETS1-1.Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.**

- **K-2-ETS1-2.Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.**

- **K-2-ETS1-3.Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.**

K-2 NGSS Disciplinary Core Ideas (DCIs)

- **ETS 1.A: Defining and Delimiting Engineering Problems**
  - A situation that people want to change can be approached as a problem to be solved through engineering. (K-2-ETS1-1).
  - Asking questions, making observations, and gathering information are helpful in thinking about problems. (K-2-ETS1-1).
  - Before beginning to design a solution, it is important to clearly understand the problem. (K-2-ETS1-1)
- **ETS 1.B: Developing Possible Solutions**
  - Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. (K-2-ETS1-2).
- **ETS 1.C: Optimizing the Design Solution**
  - Because there is always more than one possible solution to a problem, it is useful to compare and test designs. (K-2-ETS1-3).

3-5 NGSS
Science & Engineering Practices: Performance Expectations

3-5 Science & Engineering Practices

Students who demonstrate understanding can:

- **3-5-ETS1-1.Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.**

- **3-5-ETS1-2.Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.**

- **3-5-ETS1-3.Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.**

3-5 NGSS Disciplinary Core Ideas (DCIs)

- **ETS 1.A: Defining and Delimiting Engineering Problems**
  - Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Difference proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5 ETS1-1).
- **ETS 1.B: Developing Possible Solutions**
  - Research on a problem should be carried out before before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2).
  - At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5 ETS1-2).
  - Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3).
- **ETS 1.C: Optimizing the Design Solution**
  - Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3).

Teacher-Author note: I philosophically disagree with DCI 3-5-ETS1-2. With an iterative design approach, one often produces more innovative designs by *not* researching first. Design first also motivates students to have a reason to research between iterations. It's nice to have the baseline of design results before and after research as well. This challenge reflects my approach.

Middle School NGSS Science & Engineering Practices: Performance Expectations

MS Science & Engineering Practices

Students who demonstrate understanding can:

- **MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.**

- **MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.**

- **MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.**

- **MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.**

Middle School NGSS Disciplinary Core Ideas (DCIs)

- **ETS 1.A: Defining and Delimiting Engineering Problems**
  - The more precisely a design task's criteria and constraints can be defined, the more likely is is that the designed solution will be successful. Specification of constraints includes consideration of specific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1).
- **ETS 1.B: Developing Possible Solutions**
  - A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4).
  - There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3).
  - Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3).
  - Models of all kinds are important for testing solutions. (MS-ETS1-4).
- **ETS 1.C: Optimizing the Design Solution**
  - Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process – that is, some of those characteristics may be incorporated in the new design (MS-ETS1-3).
  - The iterative process of testing the most promising solutions and modifying what is proposed on the basis of test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4).

READ ME!
YOU'LL BE GLAD YOU DID!

The link above gives a text description of what students should understand about forces & interactions by the end of 2nd grade, 5th grade, and 8th grade.

It's a fantastic primer to get the most out of this STEM challenge!

PLEASE NOTE:

The physical science standards which follow on the next pages are not *explicitly* covered in the challenge *unless/until* you elect to implement some of the related post-design extension activities described in the "Teacher Tips" section of this file.

3rd Grade NGSS
3-PS2
Motion and Stability: Forces and Interactions

PS2.A: Forces and Motion

- Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative addition of forces used at this level.) (3-PS2-1)
- The pattern of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. (Boundary: Technical terms, such as magnitude, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.) (3-PS2-2)

PS2.B: Types of Interactions

- Objects in contact exert forces on each other. (3-PS2-1)

5^{th} grade NGSS
5-PS2
Motion and Stability: Forces and Interactions

PS2.B: Types of Interactions

- The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center. (5-PS2-1)

Middle School NGSS
MS-PS2
Motion and Stability: Forces and Interactions

PS2.A: Forces and Motion

- For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law). (MS-PS2-1)
- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (MS-PS2-2)
- All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared. (MS-PS2-2)

PS2.B: Types of Interactions

- Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass – e.g., Earth and the sun. (MS-PS2-4)
- Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively). (MS-PS2-5)

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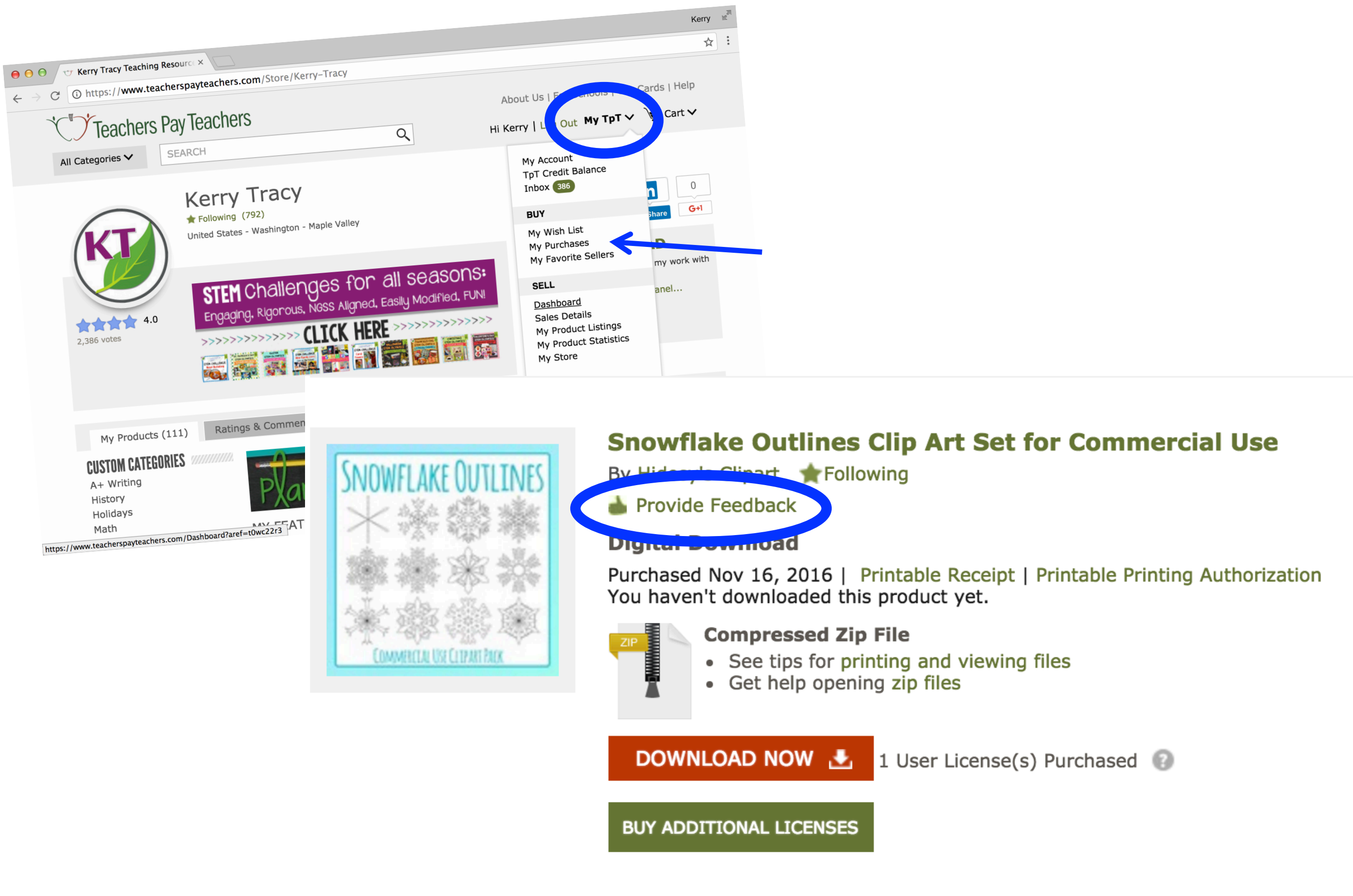

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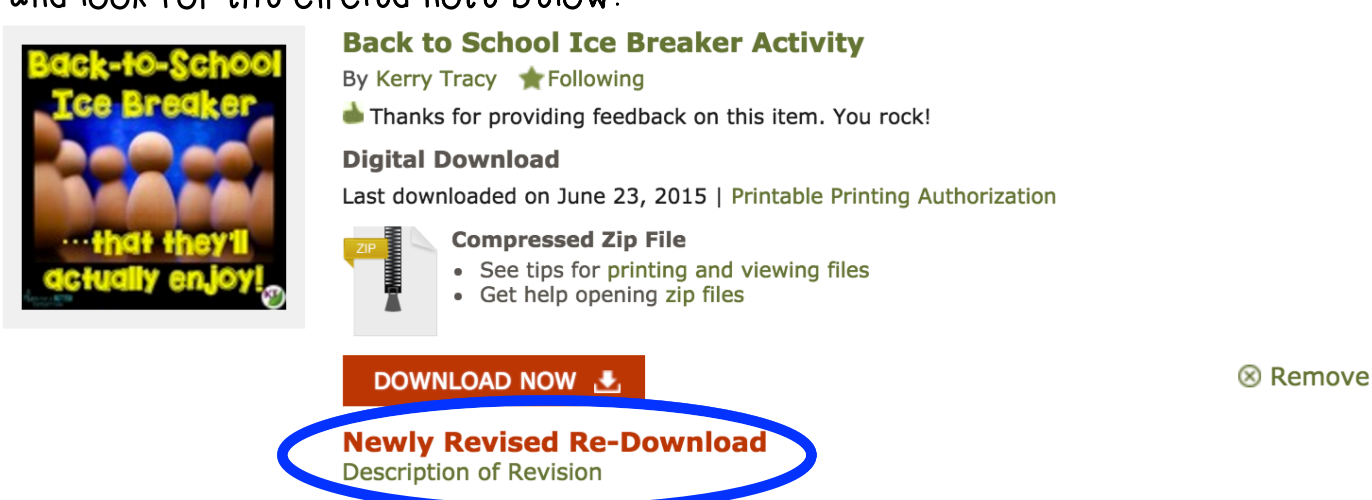

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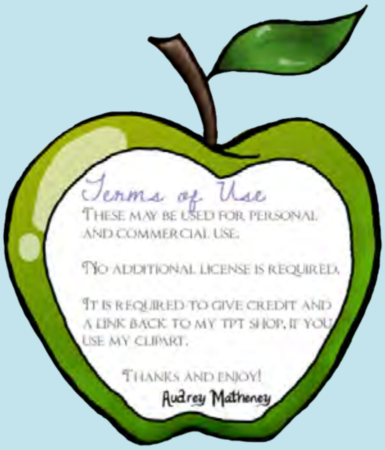

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