Egg Drop Device

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Target Grade: 9th STEM

Time Required: 90 minutes

Standards:

- Principals in Engineering and Technology: Engineering Design Process (8)- Complete a simple design activity and apply the engineering design process to produce a model than an engineer would test.
- Physics:_ Embedded Technology and Engineering - 3231.T/E.2 Apply the engineering design process to construct a prototype that meets developmentally appropriate specifications.

Lesson Objectives:

Students will:

- learn/understand momentum and how it relates to mass and velocity.
- relate the necessity of using the engineering design process with the Egg Drop challenge.

Central Focus:

The purpose of this lesson is to learn the principles of momentum and how to use the engineering design process to create a product to minimize the momentum of an egg while falling.

Background Information:

Students should be aware of the engineering design cycle prior to this lesson. These steps include the following; Define the Problem, Do Background Research, Specify Requirements, Brainstorm Solutions, Choose the Best Solution, Do Development Work, Build a Prototype, Test and Redesign. Momentum is defined as the quantity of motion of a moving body, measured as the product as of its velocity and mass. Students should be able to take information from momentum and apply it using the principals in engineering.

Materials

- Momentum Handout
- YouTube videos (https://goo.gl/d4mpkn, https://goo.gl/RcuwvZ)
- Rubric for Contest
- Egg drop contest specification sheet for Engineers Day

Instruction

Introduction:

Step 1: The teacher will refresh the students on facts about momentum. Including the following information:

- p = mv
- Momentum is a vector, pointing in the direction of the velocity.
- If there is no net force acting on a system, the system's momentum is conserved.
- A net force produces a change in momentum that is equal to the force multiplied by the time interval during which the force was applied.

The teacher will check for student understanding by asking for a thumbs up or down before proceeding to hand out the momentum handout (attached below).

Step 2: In small groups students will read, discuss, and answer questions from a Momentum handout (see attachment).

Guided Practice:

Step 3: Students are then shown momentum examples in action:

- Videos Airdrop of food in Leer https://goo.gl/d4mpkn
- Apollo 15 Splashdown https://goo.gl/RcuwvZ

Step 4: Brainstorm, as a class, ways to reduce momentum of a falling object. Write on an anchor chart or smart board ideas as your class discusses them together.

Step 5: Introduce the Egg Drop Contest as presented by the University of Tennessee's Engineers Day. Read and discuss constraints. (see attachment below)

Step 6: Discuss project relevance to the Engineering Design Process. Write the steps to the design process on the board for a visual aid.

- Define the Problem
- Do Background Research
- Specify Requirements

- Brainstorm Solutions
- Choose the Best Solution
- Do Development Work
- Build a Prototype
- Test and Redesign

Step 7: Teach will hand out and discuss the scoring rubric with students, ensuring they understand the constraints and expectations.

Closure

Step 8: As an exit ticket, students will use Google Classroom to submit an updated definition of “Momentum” and how they plan to use the Engineering Design Process to achieve their project goals

Differentiation

- Students will be put into small groups to work on the Momentum handout. This will be done with high level and low-level students, so they can help each other when the teacher is not around to assist.
- Visual aids throughout the lesson such as the engineering process and brainstorming.

Assessment

Formative

- Informal: Teacher observations will be made during the project to assess student involvement in group and individual work.
- Formal: Students’ achievement of lesson goals will be assessed through their exit ticket in Google Classroom.

Example picture

MSE Egg Drop Contest Rules

1. The competition is sponsored by the Department of Materials Science and Engineering and the Materials Research Society with the intent that the entries focus on materials selection. The objective is to design a device with a focus on the materials used that will protect a “free range” grade A egg from breaking when dropped.

2. The score will be calculated using the following equation. The lowest nonzero score wins. As can be seen from the equation below the goal is to design a device with the lightest weight, the fewest number of parts, and the most accurate drop to the Drop Zone target.

$$score = \left[\frac{30}{31}W + \frac{30}{18}N + 20DZ\right] EIF$$

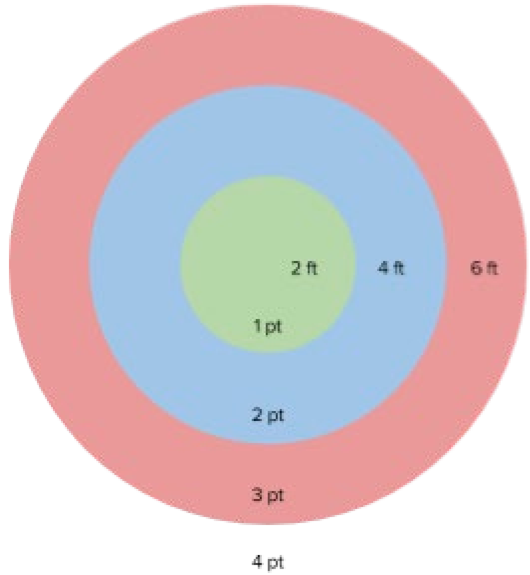
W	Weight in grams
N	Number of parts
DZ	Drop Zone
EIF	egg integrity factor (1 is not cracked or 0 if cracked)

3. Eggs will be provided on the day of the contest.

4. Each device will be weighed at the contest with no egg inside.

5. The number of parts used for the device will be counted on the day of the contest. Each individual structural component will count as one piece, and the official number of parts will be decided by a judge at the contest.

6. The Drop Zone will be comprised of three concentric rings: two, four, and six feet in diameter. A land entirely within the innermost ring will be one point, in the second ring will be two points, in the third ring will be three points, and outside of all the rings will be four points. The device will receive points based on the outmost ring in which any part of the device lies.



7. **Materials which are not allowed in construction include gases (other than air), gels, pastes, liquids, any food item, overly messy materials, and any potentially dangerous materials.** A judge will decide if any questionable devices are allowed to drop. Examples of restricted materials include peanut butter, rice, shaving cream, and helium. Please be mindful of those cleaning up after the event.

8. First, second, and third places will be announced on the Engineer's Day website following the event.

9. The entire device must be above the drop plane (even with the top of the railing) when released. It cannot be in contact with the ground, a person, or a structure. For example, a long slide may not be used to transport the egg UTK ENGINEERS DAY from the balcony to the ground.

10. Safety is a high priority, so anyone dropping their device before the drop zone is clear and their O.K. is given will be disqualified.

11. Anyone or Team may enter multiple devices as long as each design is unique.

12. Up to three modified drops will be allowed, if time permits.

13. A judge will determine if each entrant follows all contest rules.

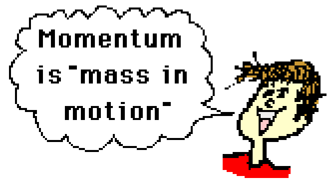
14. Drop height is about 32 ft.

15. Score sheets must be returned to the registration desk after the drop. Failure to return the sheet prevents scoring, and so the team cannot be ranked.

Momentum! What is it? http://www.physicsclassroom.com/class/momentum/u4l1a.cfm

The sports announcer says, "Going into the all-star break, the Chicago White Sox have the momentum." The headlines declare "Chicago Bulls Gaining Momentum." The coach *pumps* up his team at half-time, saying "You have the momentum; the critical need is that you use that momentum and bury them in this third quarter."

Momentum is a used term in sports. A team that has the momentum is on *the move* and is going to take some effort to stop. A team that has a lot of momentum is really *on the move* and is going to be *hard to stop*. Momentum is a physics term; it refers to the quantity of motion that an object has. A sports team that is *on the move* has the momentum. If an object is in motion (*on the move*) then it has momentum.



Momentum can be defined as "mass in motion." All objects have mass; so if an object is moving, then it has momentum - it has its mass in motion. The amount of momentum that an object has is dependent upon two variables: how much *stuff* is moving and how fast the *stuff* is moving. Momentum depends upon the variables mass and velocity. In terms of an equation, the momentum of an object is equal to the mass of the object times the velocity of the object.

Momentum = mass • velocity

In physics, the symbol for the quantity momentum is the lower-case **p**. Thus, the above equation can be rewritten as

$$p = m \bullet v$$

where **m** is the mass and **v** is the velocity. The equation illustrates that momentum is directly proportional to an object's mass and directly proportional to the object's velocity.

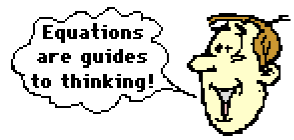
The units for momentum would be mass units' times velocity units. The standard metric unit of momentum is the kg•m/s. While the kg•m/s is the standard metric unit of momentum, there are a variety of other units that are acceptable (though not conventional) units of momentum. Examples include kg•mi/hr, kg•km/hr, and g•cm/s. In each of these examples, a mass unit is multiplied by a velocity unit to provide a momentum unit. This is consistent with the equation for momentum.

The Momentum Equation as a Guide to Thinking

From the definition of momentum, it becomes obvious that an object has a large momentum if both its mass and its velocity are large. Both variables are of equal importance in determining the momentum of an object. Consider a Mack truck and a roller skate moving down the street at the same speed. The greater mass of the Mack truck gives it a greater momentum. Yet if the Mack truck were at rest, then the momentum of the least massive roller skate would be the greatest. The momentum of any object that is at rest is 0. Objects at rest do not have momentum - they do not have any "mass in motion." Both variables - mass and velocity - are important in comparing the momentum of two objects.

The momentum equation can help us to think about how a change in one of the two variables might affect the momentum of an object. Consider a 0.5-kg physics cart loaded with one 0.5-kg brick and moving with a speed of 2.0 m/s. The total mass of *loaded* cart is 1.0 kg and its momentum is 2.0 kg•m/s. If the cart was instead loaded with three 0.5-kg bricks, then the total mass of the *loaded* cart would be 2.0 kg and its momentum would be 4.0 kg•m/s. A doubling of the mass results in a doubling of the momentum.

Similarly, if the 2.0-kg cart had a velocity of 8.0 m/s (instead of 2.0 m/s), then the cart would have a momentum of 16.0 kg•m/s (instead of 4.0 kg•m/s). A *quadrupling* in velocity results in a *quadrupling* of the momentum. These two examples illustrate how the equation p = m•v serves as a "guide to thinking" and not merely a "*plug-and-chug* recipe for algebraic problem-solving."



Check Your Understanding

Express your understanding of the concept and mathematics of momentum by answering the following questions.

1. What is *momentum* scientifically speaking?
2. Determine the momentum of a ...
   a. 1000-kg car moving northward at 20 m/s.
   b. 40-kg freshman moving southward at 2 m/s.
3. A car possesses 20 000 units of momentum. What would be the car's new momentum if ...?
   a. It's velocity was doubled.
   b. It's velocity was tripled.

Engineering Design Process Evaluation Rubric

	Score 4	Score 3	Score 2	Score 1	Score 0
Brainstorm	Student uses prior knowledge and lesson content knowledge to brainstorm a clear, focused idea(s). Idea(s) are *excellently* aligned to the intent of the problem.	Student uses prior knowledge and/or lesson content knowledge to brainstorm a clear, focused idea(s). Idea(s) are *aligned* to the intent of the problem.	Student uses prior knowledge and/or lesson content knowledge to brainstorm an idea(s). Idea(s) are *minimally* aligned to the intent of the problem and a clear connection is not readily apparent without explanation.	Student uses prior knowledge and/or lesson content knowledge to brainstorm an idea(s). Idea(s) are *impractical* for the intent of the problem and/or connection to the problem is *inadequate or unclear*.	Brainstorming idea(s) are not aligned with the intent of the problem, or no idea(s) were given by the student.
Design Plan	Student proposes and designs a plan that *excellently* aligns with the criteria, constraints, and intent of the problem. Technical drawing is complete and includes *exceptional, relevant* details that will be referenced when building the solution to the problem.	Student proposes and designs a plan that *adequately* aligns with the criteria, constraints, and intent of the problem. Technical drawing is complete and includes details that will be referenced when building the solution to the problem.	Student proposes and designs a plan that *minimally* aligns with the criteria, constraints, and intent of the problem. Technical drawing is complete, and a clear connection is not readily apparent without explanation.	Student proposes and designs a plan that does not align with the criteria, constraints, and intent of the problem. Technical drawing is *impractical* and/or connection to the problem is *inadequate or unclear*.	Design plan is not completed by the student.

Engineering Design Process Evaluation Rubric

Build a Working Model (Prototype)	Student builds a working model that *excellently* aligns with the criteria, constraints, and intent of the problem. The working model can be tested using appropriate tools, materials and resources.	Student builds a working model that *adequately* aligns with the criteria, constraints, and intent of the problem. The working model can be tested using appropriate tools, materials and resources.	Student builds a working model that *minimally* aligns with the criteria, constraints, and intent of the problem. The working model can be tested using *modified* tools, materials and resources.	Student builds a working model that *does not align* with the criteria, constraints, and intent of the problem. The working model can be tested using *modified* tools, materials and resources OR completed working model cannot be tested.	Working model is not built.
Test and Redesign	Student tests the working model's effectiveness to solve the problem. *Accurate and detailed* records are collected, and an analysis of data is present. Student uses data to redesign the working model into a more effective solution that aligns with the criteria, constraints, and intent of the problem.	Student tests the working model's effectiveness to solve the problem. *Adequate* records are collected, and an analysis of data is present. Student uses data to redesign the working model into a more effective solution that aligns with the criteria, constraints, and intent of the problem.	Student tests the working model's effectiveness to solve the problem. *Minimal* records are collected. Analysis of data is *not* present. Student uses data to redesign the working model into a more effective solution that aligns with the criteria, constraints, and intent of the problem.	Student tests the working model's effectiveness to solve the problem. *Minimal* records are collected. Analysis of data is *not* present. Student does *not redesign* the working model.	Testing is not performed due to either an inability to test based on the quality of the working model, or there is no working model to test.