Science Assessment System
Through Course Task

Save the Egg

Grade Levels:
6, 7, 8, 9

Phenomena:
Air Resistance/Friction/Drag

Science & Engineering Practices:
Developing and Using Models; Analyzing and Interpreting Data
Constructing Explanations and Designing Solutions
Engaging in Argument from Evidence

Crosscutting Concepts:
Cause and Effect

Designed and revised by Kentucky Department of Education staff
in collaboration with teachers from Kentucky schools and districts.

Preparing to implement Through Course Tasks in the Classroom

What is a TCT?

- TCTs are 3-dimensional tasks specifically designed to get evidence of student competency in two dimensions, Science and Engineering Processes (SEPs) and Crosscutting Concepts (CCC), untethered from Performance Expectations (PEs)/standards. Tasks are sense-making experiences.
- Tasks are to be used formatively. The goal is for both students and teachers to understand areas of strength and improvement for the SEP(s) and CCC assessed within the task.

How do I facilitate a Through Course Task (TCT)?

- TCT facilitation is a collaborative process in which teacher teams calibrate understanding of the expectations of the task and refine strategies to be used during task facilitation.

Before the task:

1. Complete the TCT as a learner – compare understanding of task through the lens of success criteria (identified in the task) in order to understand expectations.
   Success criteria include:
   - What is this task designed to get evidence of?
   - What is the task asking the students to do?
   - What might a student response look like?
2. Identify the phenomenon within the task. Consult resources to assure teacher teams have a deep understanding of associated science concepts.
3. Collaborate to generate, review and refine feedback questions during facilitation.
4. Identify potential “trouble spots” and plan for possible misconceptions.

During the task:

5. Collect defensible evidence of each student’s competencies in 3-dimensional sense-making for the task.
6. Ask appropriate feedback questions to support student access and engagement with the task in order to elicit accurate evidence of student capacities.

After the task:

7. Reflect on the task as a collaborative team.
8. Review student work samples to identify areas of strength and areas of need.
9. Determine/plan next steps to move 3-D sense making forward through the strengthening of the use of SEPs and CCCs.

Using the materials included in this packet:

- **Task Annotation:**
  - The task annotation is a teacher guide for using the task in the classroom. Additionally, the annotation gives insight into the thinking of developers and the task overall.

    - Each task has science and engineering practices, disciplinary core ideas, and crosscutting concepts designated with both color and text style:
        - **Science and Engineering Practices**
        - *Disciplinary Core Ideas*
        - Crosscutting Concepts
- **Student Task:** The materials to be used by students to complete the TCT.

Save the Egg Task Annotation

(Students will **analyze and interpret data** about *parachute drop times* **to describe the relationship** between *drop time and* parachute size based on patterns in the data.*) Students will then **develop models** *of the forces acting on eggs with different parachute sizes* **to explain** the cause and effect relationship between the *overall net force acting on the falling egg and parachute size*.

*The task template in parentheses is a mini-task included to set up engagement and context for the second task template.

Overall intent

The culmination of this task should provide evidence of a student's ability to explain the causal mechanism by which parachutes provide protection to falling eggs, using force models to support the explanation for why a larger parachute would provide better protection for a falling egg. Initially, the task evaluates a student's ability to analyze and interpret data to identify and describe patterns in a data set of 2 variables (drop time vs. parachute size). This initial mini-task is intended to set-up the larger assessment intent. After identifying the relationship, students are expected to explore the causal mechanism by using force models, and then explain why a larger parachute would provide better protection for a falling egg, using the models to support the explanation.

Phenomenon within the task

A falling object (egg) has a downward force acting on it due to gravity. Air resistance acting on the falling egg results in an upward force, and these 2 forces oppose each other. Adding a parachute to the egg increases the upward force due to increased air resistance (drag), and the resulting force (net force) is smaller with a parachute than without a parachute – thus, an egg with a parachute hits the ground with less force. In general, an egg with a bigger parachute results in more air resistance than a smaller parachute. Thus, when dropped from the same height, an egg with a larger parachute takes longer to hit the ground, and it hits the ground with less force.

Ideas for setting up the task with students

1. Before asking students to grapple with the data in Section A, build three simple parachutes of different sizes using plastic bags, string, and an object. Then, demonstrate the different parachutes by releasing the parachute and object and allow them to reach the floor. You may want to demonstrate a couple of times, asking students to observe differences. This will allow all students the opportunity to understand the data they are asked to make sense of. Then, introduce section A.

2. It may be that the data as presented in the table in Section A is overwhelming to some students. It might be useful to have students analyze the data table first, and describe the data that is contained in the table. For example, students could work in small groups to explain the information that the data table conveys, and then share the explanation with the class. One group could explain first, and subsequent groups could add to or refine the previous explanation, and the whole class could agree on a good explanation of the data contained in the table. This would remove the issue of understanding the data table (columns of collected data that are averaged) as a hindrance to the assessment intent. It's important to stress that the purpose of the explanation is not to interpret the data, but to understand what information is in the data table.
3. Ask students who are struggling with the analysis and interpretation of the data, to visualize the experimental design necessary to collect the data. After visualizing, the reasoning necessary to analyze and interpret is less abstract.
4. Tell students they may find multiple patterns in the data, but remind them to describe a pattern that benefits the design of the egg contraption, whose intent is to keep the egg from breaking.
5. Students must have experience with force diagrams before using this task, which means they need to understand the how forces act on objects, they have to understand the use of models to explore and explain, and they must be able to combine these two concepts. This is a significant cognitive load. It is not recommended to frontload each of these concepts just prior to using this task, but rather to ensure that students have been exposed to these concepts in the normal course of instruction.

   Students will need to understand that scientists use "free body diagrams" (FBD) to model forces acting on objects. See this resource for additional information, http://www.physicsclassroom.com/class/newtlaws/Lesson-2/Drawing-Free-Body-Diagrams. For a falling egg, the force diagram only has forces acting in one dimension (up and down) so the situation is not as complex as is frequently discussed in physical science resources.
6. Force diagrams model the size and direction of forces acting on an object. For example, in Diagrams A and B the force of gravity is opposite of the air resistance force. Plus, the air resistance force is shown to be larger in Diagram A versus Diagram B because the arrow is larger, but the force of gravity is the same in each diagram and needs to be taught in class.

Diagram A could be a model of a larger parachute than Diagram B, but this should not be shared with students.

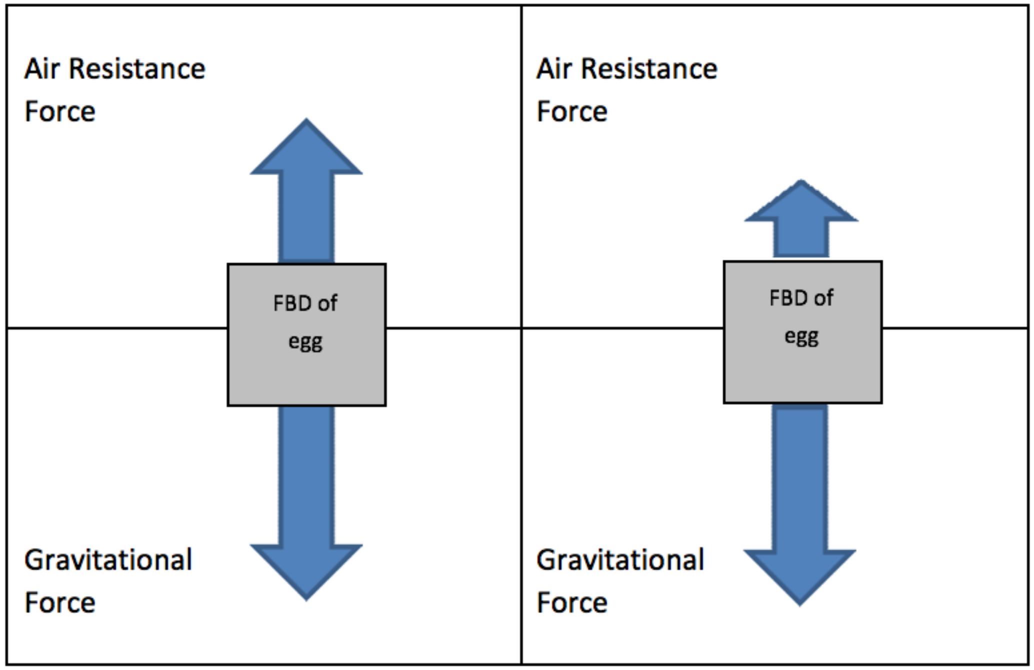


Diagram B

One strategy to support student learning is to use paper arrows (of different sizes) taped to rulers to model the forces is a concrete way to practice modeling forces before the use of force diagrams.

7. Students may need scaffolding. While other scaffolds may be needed, consider these prompting questions:
   "Why do you think there is a grid provided with the egg models in part C?"
   "What is common between each of the models in part C?"
8. The vocabulary term <u>Net Force</u> is used in the task, and it's important that students understand the concept rather than the term. <u>Resultant Force</u> is another term that could be used to describe this concept, and there could be others. Understanding the specific vocabulary is not the goal (although it is the language used in the task), but understanding the effect of

combining forces in the same dimension is important. Adding numbers to Diagram A and B, will make the concept more concrete. For example in Diagram A, if the Air resistance force is +4 and the gravitational force -6, then the net force would be -2. In Diagram B, if the air resistance force is +2 and the gravitational force stays the same (-6), then the net force would be -4. The net force would be greater in Diagram B than Diagram A.

Intent of the Task for Assessment

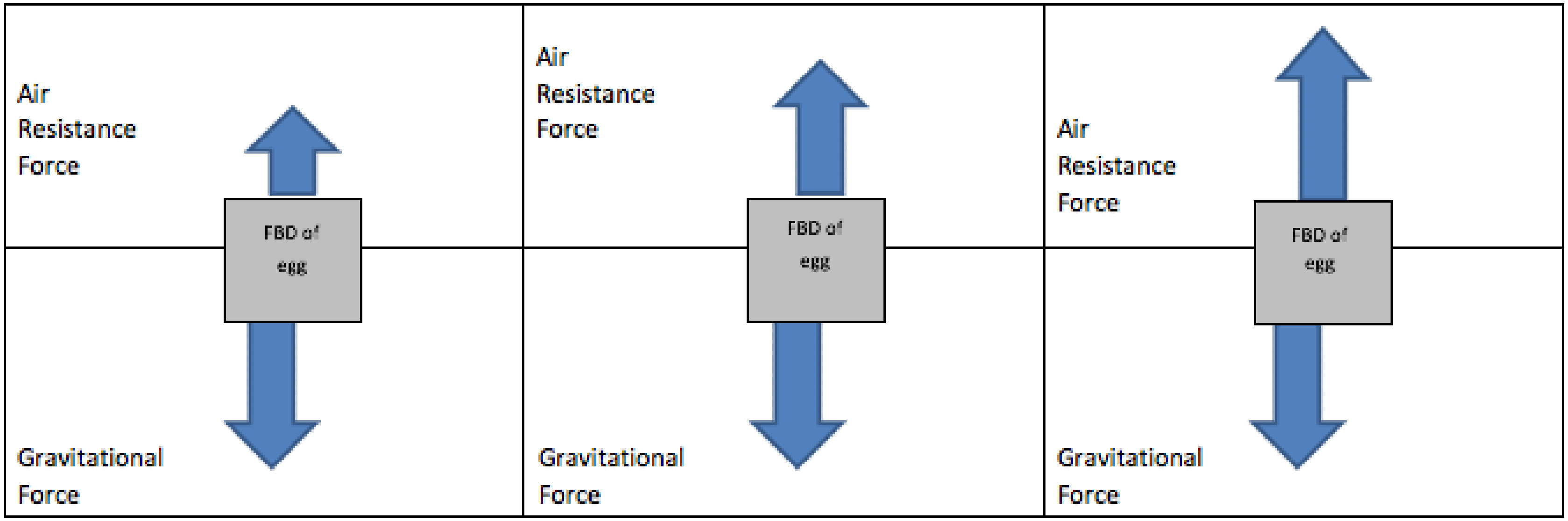
The primary assessment intent of this task is to provide evidence of a student's ability to use models to explain their scientific thinking about a causal mechanism. All other parts of the task exist to support obtaining this evidence.

Part of the understanding we seek by using egg drop experiences with students (larger parachutes cause the egg to fall slower and hit the ground with less force) is generally intuitive to most students. However, scientifically explaining why parachutes are effective in protecting a falling egg is frequently neglected. Thus, engagement with this task should be high due to familiarity and the skills and understandings necessary to explain why parachutes are useful should be ripe for obtaining. Students will need to be reminded often to be deliberate in their use of data and models to support their explanation.

Part A of the task should provide evidence of student's ability to identify and explain a pattern based on analysis of data provided, but is also included as engagement to thinking about how eggs fall, and factors that affect the way eggs fall. Suggestion #2 in setting the task up with students might be necessary to get accurate evidence of students identifying the correct relationship/pattern. Part A might get students to begin to think about cause, but the evidence of student understanding obtained is identifying and explaining a pattern based on analysis of data provided.

Part B should provide clear evidence that a student has accurately identified the general relationship between drop time and parachute size for the data presented by using the pattern to extrapolate to an even larger sized parachute. Thus, there should also be evidence of the student's ability to use the relationship, and not just identify it. Students may choose to use number values or a narrative to describe the increase in drop time.

Part C should provide evidence that a student understands force diagrams to model the falling egg. It's very possible that some students will need more scaffolding than others in this section, particularly the lower the grade level and less experience with modeling forces. Teachers should note the amount and type of scaffolding needed for certain students, but should ensure that students can use the models effectively before students proceed to Part D. Thus, students may be developing understanding of force diagrams during this part of the task, but in Part D students will demonstrate their ability to use the model in an explanation.



Part D prompts students to use the models to explain the real world event of saving the egg. Furthermore, the students are prompted to use their scientific reasoning to explain how different combinations of opposing forces decide the fate of the egg. This is the culmination of the task and should provide accurate evidence of a student's ability to construct an explanation using a model.

List components of the task / resources used with the task

The task document and this annotation are the only resources provided with this task.

Success Criteria

Evidence of Learning Desired based on Progression from Appendices

- Students analyze, and interpret graphical displays of data to identify relationships (App F – Data)
- Graphs, charts, and images can be used to identify patterns in data. (App G – Patterns)
- Develop and use a model to describe a phenomenon. (App F – Models)

- Construct an explanation that includes qualitative relationships between variables. Construct an explanation using models. (App F – Explanations)
- Patterns can be used to identify cause and effect relationships. (App G – Patterns)

Success Criteria

- Students will accurately describe the relationship between parachute size and drop time. It is reasonable to infer that students can accurately analyze and interpret the provided data.
- Students will use the identified pattern to accurately predict a drop time in an appropriate range for a parachute size of 20" diameter based on the data presented.
- Students will create accurate force diagrams to represent the forces acting on the 3 sizes of parachutes.
- Students will construct an explanation that describes the relationship between parachute size and net force on a falling egg, and support the explanation with evidence from their force models.

Possible Student Responses (these are not "look fors" but are simply examples to support understanding of the task)

- As the parachute size increases, the drop time increases.
- An increase in the parachute size will also increase the drop time.
- I would expect a 20 inch diameter parachute to take longer than 20 seconds based on the data provided.

** Students don't have to use a numerical value, but the description must be accurate and reference the data.

- Force Diagram Model should be labeled and include:
  1. Arrows representing gravitational force:
     - Point Down
     - Must be equal in size for the 3 models
     - Must be larger than air resistance arrows
  2. Arrows representing air resistance:
     - Point up
     - Get larger as the parachute gets larger
     - All must be smaller than gravity arrows or the egg would not fall

- The force diagrams show a larger parachute produces more air resistance opposing the gravitational force and producing a smaller net force applied to the egg. Therefore, a larger parachute gives the egg a better chance of surviving (not cracking) because the smaller the net force, the slower it will fall and the softer it will hit the ground.

Other information teacher teams might find useful when preparing to use this task in the TCT process

- *Make sure students have been taught to model appropriately, including labels.*
- *A lesson in force diagrams essential if not already taught.*
- *In past administrations of this task, misconceptions involving the force of gravity changing were repeatedly noted.*

Extensions and/or other uses after the task is implemented

- Use a force diagram to model the absence of a parachute. Will students create a force diagram without an arrow representing the air resistance force? Will students recognize air resistance is still present in the system?
- Use a force diagram to model dropping a parachute on a planet like Earth that has a gravitational force twice the size of Earth.
- Have students use the design process to design, build and test an egg drop contraption of their own. Focus on the design process (criteria and constraints). As students go through the process, continue to prompt students to use their reasoning about opposing forces as they share their new designs.

Through Course Task – Save the Egg

Name: _______________________________ Date: ____________________

A group of students collected the following data for an egg drop contraption they developed:

Drop Time vs. Parachute size

	5 inch Parachute	**10 inch Parachute**	**15 inch Parachute**
Trial 1	4s	10s	17s
Trial 2	6s	9s	20s
Trial 3	5s	11s	18s
Trial 4	6s	9s	17s
Trial 5	4s	12s	16s
Average	5s	10.2s	17.6s

A. After analyzing the students' data to identify a pattern, describe the relationship between drop time and parachute size.

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B. Using the relationship you identified, predict/estimate how the drop time would change if the parachute tested was 20 inches in diameter.

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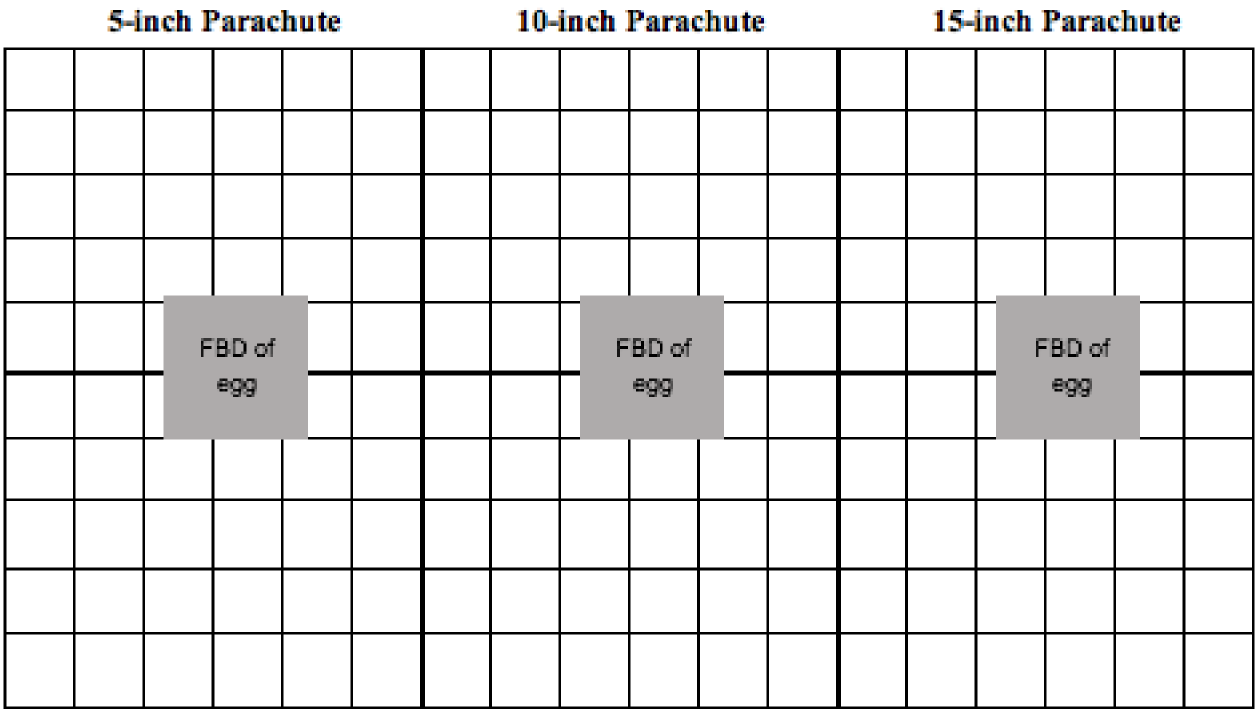
Excited by what they observed in the data, the students wanted to better understand **what actually caused** the change in drop time. They realized that **a longer drop time resulted in the egg hitting the ground with less force**, so they thought it might be useful to create models to help understand the forces acting on the egg for different parachute sizes.

C. Use the diagrams below to model the forces acting on a falling egg for each parachute size. Use arrows to model the force due to gravity and the force of air resistance. Make sure that the length of the arrows represents the relative size of each force acting on the egg for that parachute configuration.



D. Use the force diagram models from Part C to estimate the relative net force on the falling egg for each configuration. Construct an explanation for why increasing parachute size results in the egg hitting the ground with a smaller force, thus saving the egg. Support your explanation using your force models and analysis of net force for each configuration.