Science Assessment System Through Course Task

Airbag Effectiveness

Grade Level:
9, 10, 11, 12

Phenomena:
Airbag's Effect on Momentum

Science & Engineering Practices:
Analyzing and Interpreting Data
Constructing Explanations and Designing Solutions

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.

Airbag Effectiveness Task Annotation

After **analyzing the data** from trials of *a test dummy colliding with various airbag designs*, **construct a written argument** for *which airbag design provides the most protection* using patterns from the data **as evidence to support your claim.**

Phenomenon within the task

Impulse is a measurement of the total force applied to an object over time, and is equivalent to the change in the object's momentum. In a car crash, airbags give protection to passengers by slowing down the passengers over a longer period of time, which consequently reduces the amount of force applied to the passenger. This generally reduces the severity of injuries of sustained in the car crash.

One common way to evaluate this phenomenon is to collect force measurements over time, using tools such as a force plate (or other force-measuring device) paired with a data collection program. In this task, we present students with raw data from one set of demonstrations using these tools. This data serves as an analogous data set to an actual set of airbag tests, in which several airbag designs are tested in crash simulations. Experimental force and time data are provided for analysis within the task.

Often students talk about how the airbag "cushions" the passenger to reduce injury, without thinking or speaking in terms of magnitude of the force or the time duration of the force. The data presented in the table offers an opportunity for the student to consider how an airbag "works" (protects a passenger), using these variables.

How the phenomenon relates to DCI

This task relates to the study of momentum and impulse. The following DCIs are at least partially connected:

PS2.A: Forces and Motion

- Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2-1)
- Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (HS-PS2-2)
- If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS-PS2-2),(HS-PS2-3)

This task provides an opportunity for students to use SEPs and CCCs to make sense of "real data" in an authentic context that is consistent with DCIs they are intended to master through their exploration of force and motion at the high school level. This task could be used as a jumping point during a momentum-impulse unit.

What information/data will students use within this task?

- Students will use the results from the provided data table of force vs. time for different airbag designs.
- Students may need some support with the explanation of how an airbag provides protection to a passenger. This is important in being able to explain their analysis of the data; if students don't understand how an airbag provides protection, then making useful sense of the data will be significantly compromised.
- Students with less experience may have better access to the task if it is broken into multiple parts.

Ideas for setting up the task with students

- This task can be used within the curriculum or following the curriculum depending on how you want students to demonstrate their understanding.
- During the curriculum, students can prepare for this task in a number of different ways. Optimally, if access to a force plate and data collection program (e.g. Logger Pro) is available, then a demonstration or activity that involves collecting similar data using a bocce ball and various types of materials (e.g. carpet, a pillow) would help students better visualize the data/process described in this task.
- Another option would be to conduct a qualitative video analysis of falling objects hitting various cushioned surfaces, versus hitting the floor showing how the time of the collision can change. Egg drop activities help to highlight the content contained within this task as well.

Intent of the Task for Assessment

This task provides evidence of a student's ability to analyze data sets that are similar (force vs. time) but differ in their characteristics, and then communicate the differences among the data sets or summarize their analysis. This general analysis can be done even if a student doesn't understand how an airbag protects a passenger – students can still analyze and summarize the data. Part 2 of the task is included to have students reflect and express how an airbag provides protection to a passenger in a crash so that

evidence of student understanding is documented. The teacher should make sure that each student has an understanding of how an airbag provides protection before engaging with part 3 of the task. If this is not feasible for some reason, then the student's answer to part 2 will provide evidence of why a student might not have success with their argument in part 3.

Part 3 of the task provides evidence of a student's ability to develop an argument that identifies which airbag in the task will provide the most protection, using patterns they identify in their data analysis as evidence to support their argument; the argument should provide reasoning why this airbag will provide the most protection, by connecting their understanding of how airbags provide protection and their data analysis. The task is structured to help identify specific strengths and weaknesses with respect to data analysis using patterns, and then in developing an authentic argument. Furthermore, students may provide evidence of their mastery and confidence with PS2.A (forces & motion), depending of the depth of the response to part 3; the task wording does not specifically request that level of detail because that was not the primary intent. As such, this task can be used prior to specific experiences with impulse/momentum.

Success Criteria

Evidence of Learning Desired based on Progression from Appendices

Analyze and Interpret Data

- Analyze and interpret data using tools, technologies and/or models in order to make a valid and reliable scientific claim

Engage in Argument from Evidence

- Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.

Patterns

- Empirical evidence is needed to identify patterns.

Success Criteria

- The student provides an analysis of all configurations, describing the patterns they see with respect to force, time or both.
- The student develops a written argument to claim which airbag provides the most protection to a passenger during a crash based on their analysis of the data and understanding of how an airbag protects a passenger as evidence and reasoning to support their claim.

Possible Student Responses

Make a graph of force vs time.

Make a table of time range of collisions.

Identify min and max forces for each collision.

Make a table showing characteristics for each collision.

Design 1: Medium time/highest recorded force = 127.6 kN

Design 2: Most time/ highest recorded force = 91.87 kN

Design 2: Medium time/ highest recorded force = 147.5 kN

No Airbag: Lowest recorded time/ highest recorded force = 232.58 kN

The design that provides the most protection is the passenger in design 2! It is the only design that takes up to 0.060 seconds. It has the largest time, therefore it has the lowest amount of force put on the passenger. On average, it has relatively small forces compared to the other designs.

I believe that airbag design 2 has the best design as it reduces the passenger's forces more than the other designs.

Design 2 has the most force applied. I can tell based on my graph. Even though design 1 and 3 have higher numbers, 2 was maintained with only two points marked as 0.00. That would overall keep the passenger safe.

A trend present is the longer the impact takes, the less force put on the person. This, in turn, makes it safer.

All are parabolas, the impacts that took less time has considerably more forces. The more time a collision took, the force was smaller.

If an object hits a bag with less force that means the airbag slowed the head down enough to not create a greater force.

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

Many students are not able to explain an airbag using physics vocabulary so working through the data analysis and question 2 are essential to provide a good argument. If I were to do this again, I would do the task closer to when we are covering momentum-impulse.

Extensions and/or other uses after the task is implemented

- Engage students with analogous phenomena, force vs. pressure.
- Select a few examples of the students' data analyses, and have the students evaluate characteristics that make the different analyzes effective or ineffective.
- Select a few of the students' arguments with differing "issues," and have students analyze in small groups.

Through Course Task – Airbag Effectiveness

Background

Airbags are engineered to be as protective as possible during car crashes. Because of this, the process of testing airbags in car crash simulations is a robust process, and precise data must be collected in order to produce the optimal design.

One way to assess the effectiveness of an airbag in a simulated car crash is to collect force measurements over time. When a crash test dummy collides with the airbag, the force applied to the dummy is measured and recorded by a computer after each--usually very short--time interval during the simulation.

Researchers recorded the force on a dummy in a series of car crashes. In each of the crashes, the car was going 40 mph and crashed into a concrete wall. Researches recorded the forces over a short period of time (0.065 s) for three different airbag designs as well as one crash without airbags.

Your task is to analyze the data from the trials listed below. Use this analysis to construct an argument about which airbag design provides the most protection, citing patterns from the data as evidence for your claim.

The Data

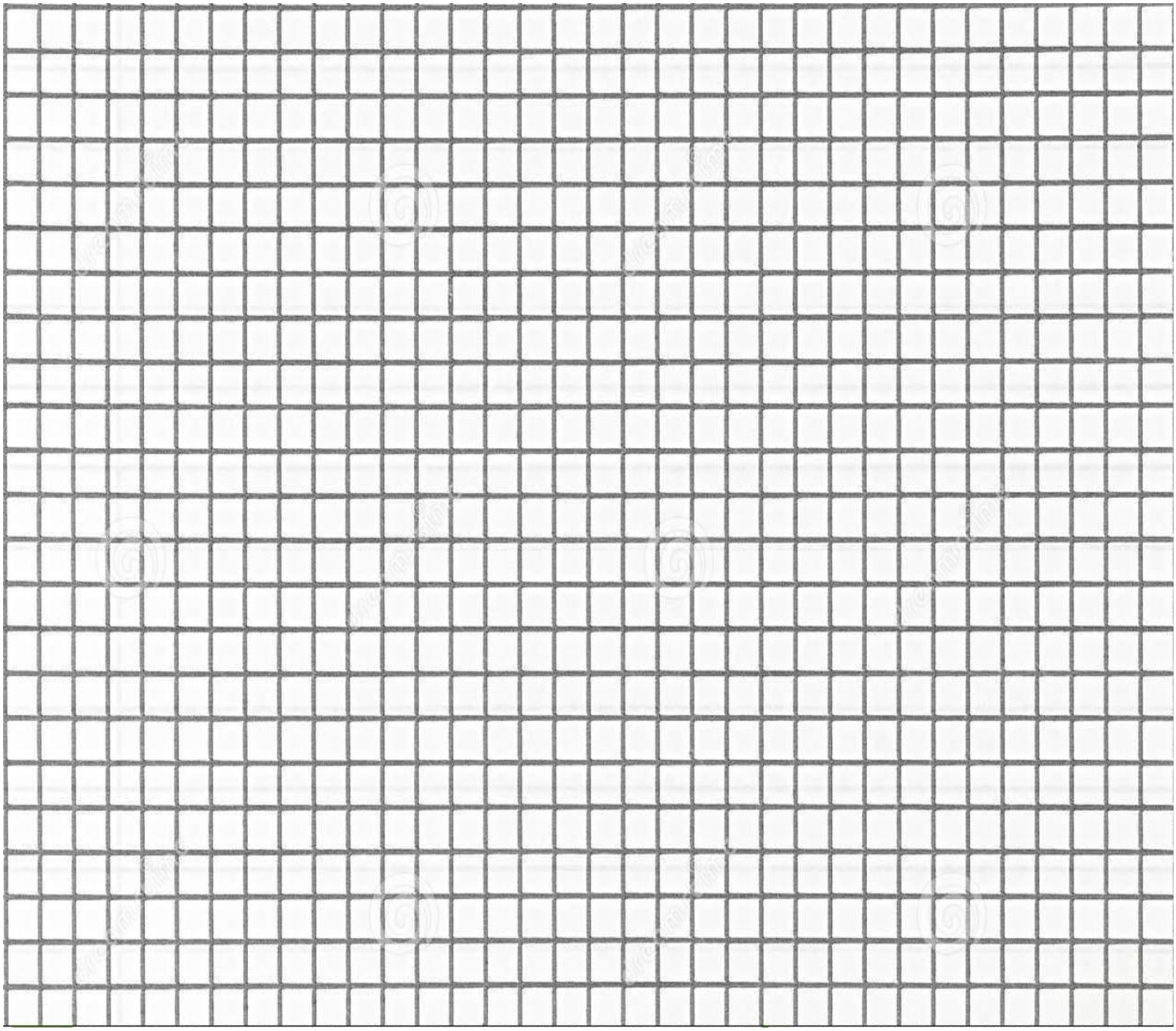
Collision of a Dummy using Various Airbag Designs

	Force (kilonewtons)			
Time (sec)	Design 1	Design 2	Design 3	No Airbag
0	0.00	0.00	0.00	0.00
0.005	0.00	7.38	0.00	0.00
0.010	0.00	46.18	8.65	2.30
0.015	7.63	84.08	33.45	5.72
0.020	56.03	91.87	83.88	232.54
0.025	101.84	90.08	147.50	222.68
0.030	126.81	81.03	111.23	67.44
0.035	114.13	54.13	77.43	16.23
0.040	64.84	36.96	36.55	4.17
0.045	38.15	29.96	22.76	0.00
0.050	17.78	18.20	9.43	0.00
0.055	5.04	10.87	0.00	0.00
0.060	0.00	4.31	0.00	0.00
0.065	0.00	0.00	0.00	0.00

*Name*_____

The Task

1. In the space below, provide an analysis of the data provided to you. You may use computation, a verbal description/comparison of the data, graphs or some other visual representation in your analysis. *Be sure to state any patterns you determine to be true from the data*.



2. How does an airbag provide protection to a passenger in a crash?

3. On the lines below, construct a written argument for which airbag design provides the most protection to a passenger. Support your claim with evidence and reasoning based on your analysis from Question 1 and your understanding of how an airbag provides protection to a passenger.