Lesson 11: Answer Key 1

Survivability versus Length Key

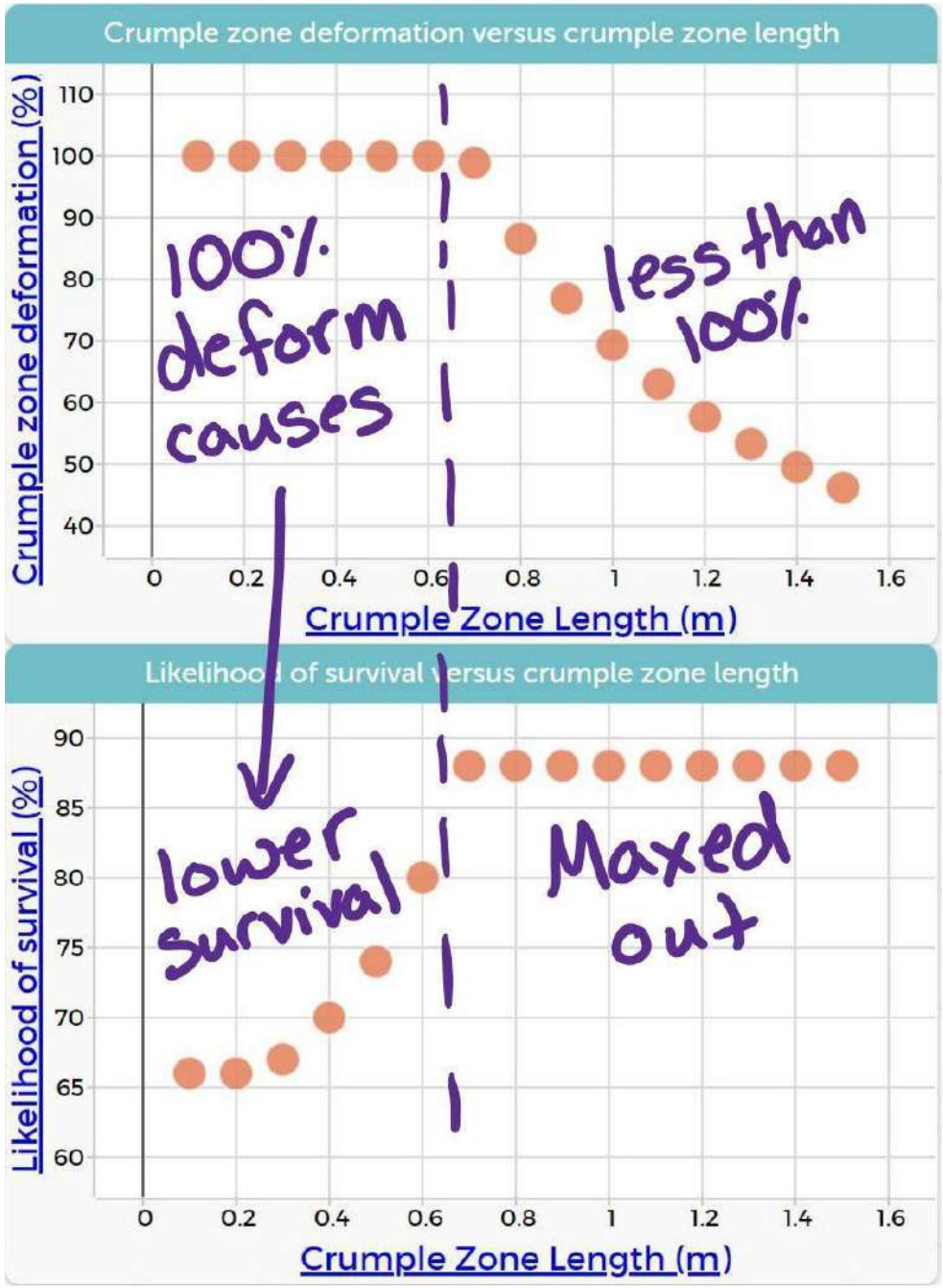
Lesson-level performance expectation being assessed

11.A Analyze patterns in graphical data from simulated collisions to make and support scientific claims about how the rigidity and the length characteristics of the crumple zone of a vehicle can be designed to optimize safety during a collision. (SEP: 4.6, 5.2; CCC: 1.3, 2.3; DCI: PS2.A.1)

	3-D elements addressed in this assessment	Part 1	Part 2, Q1	Part 2, Q2
SEPs	**4.6 Analyzing and Interpreting Data.** Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.	X	X	
	5.2 Using Mathematics and Computational Thinking. Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.			X
CCCs	**1.3 Patterns.** Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system.	X	X	X
	2.3 Cause and Effect. Systems can be designed to cause a desired effect.	X		X
DCIs	**PS2.A.1: Forces and Motion** Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2-1)		X	X

Part 1

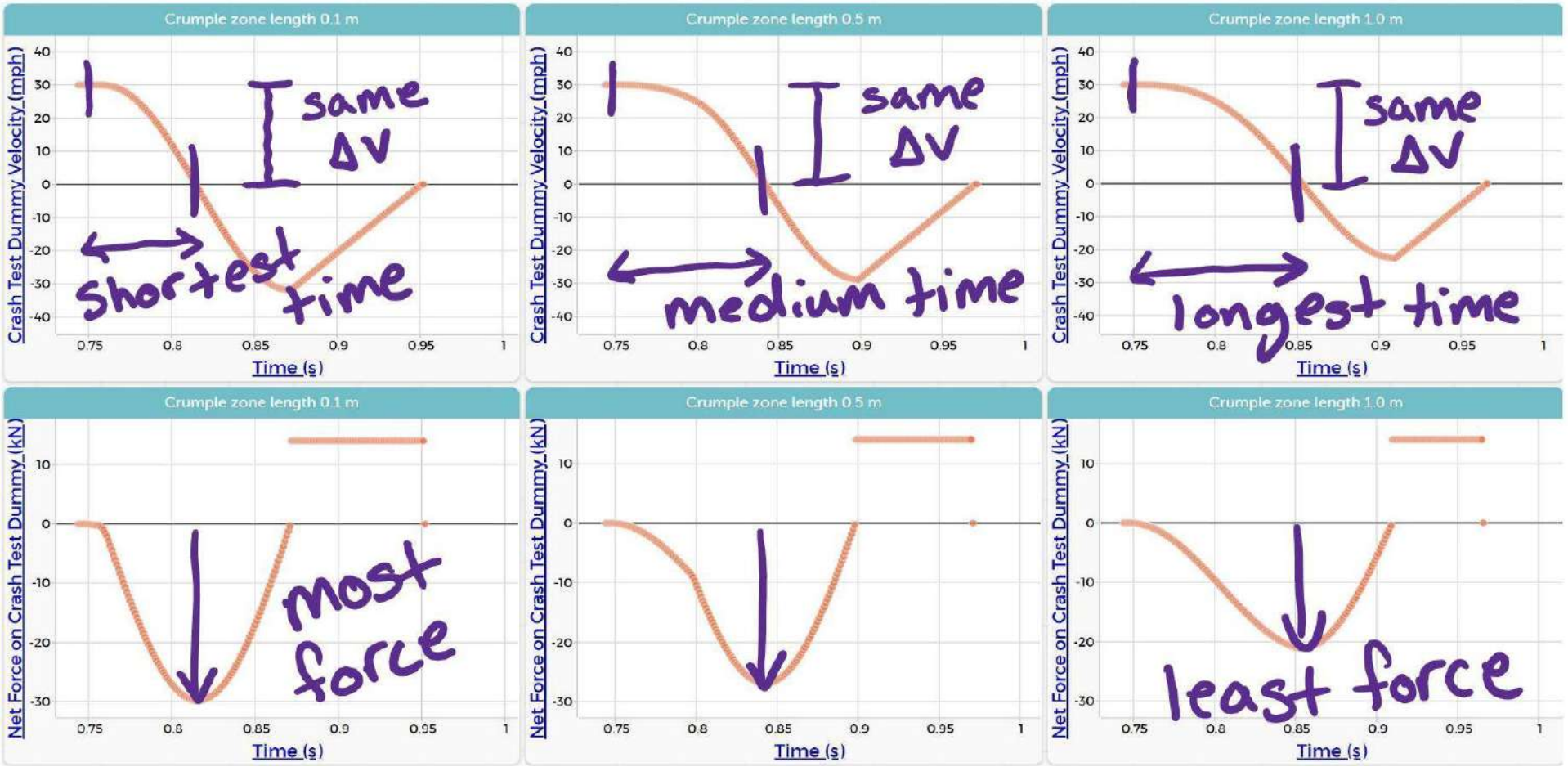
Example student annotations shown on graphs below.


Crumple zone deformation versus crumple zone length
Crumple zone deformation (%)
110
100
90
80
70
60
50
40
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
Crumple Zone Length (m)
100% deform causes
less than 100%
Likelihood of survival versus crumple zone length
Likelihood of survival (%)
90
85
80
75
70
65
60
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
Crumple Zone Length (m)
lower survival
Maxed out

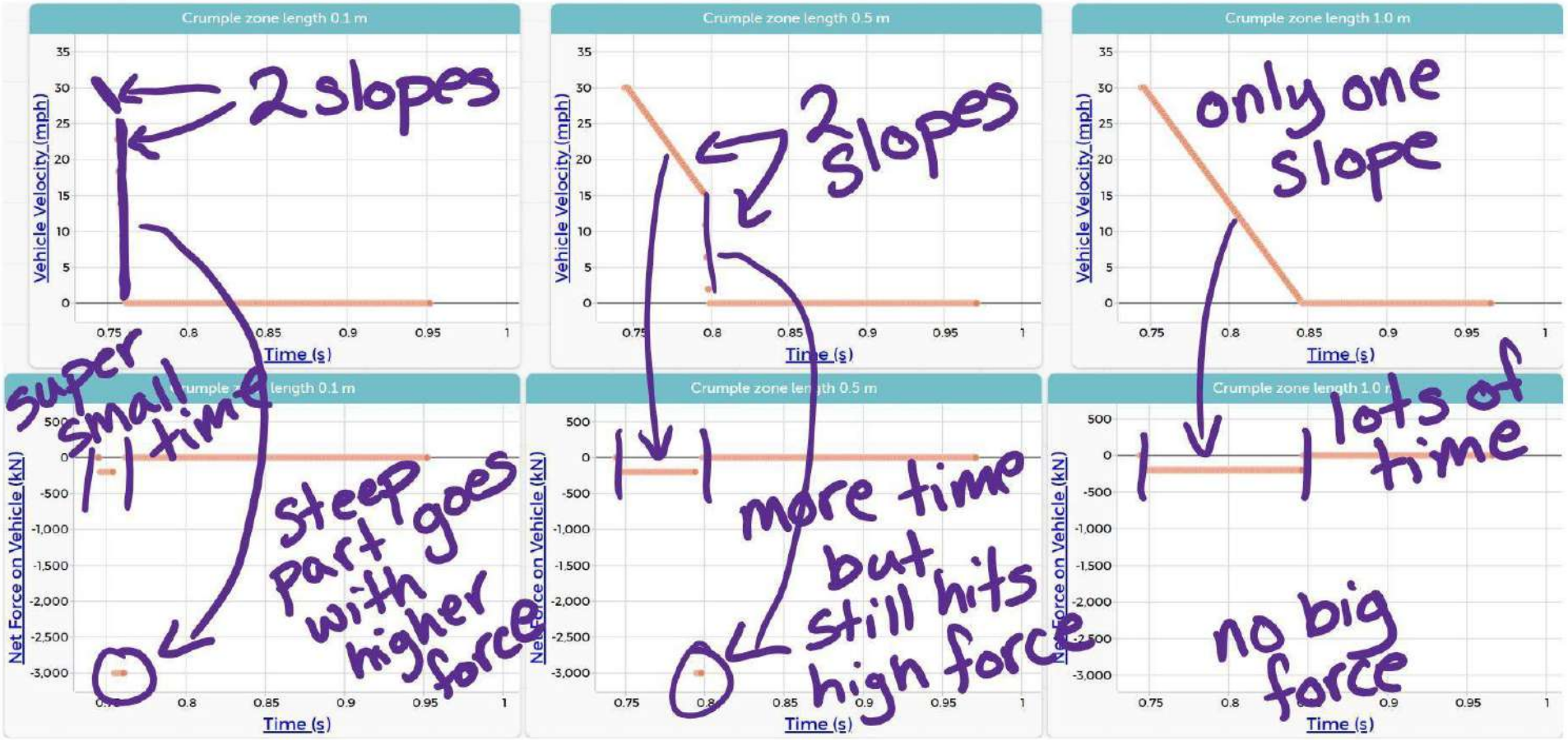
Part 2

1. Analyze and annotate the following graphs to explain how the design of the crumple zone length affects safety of the crash test dummy. The data in the graphs are for vehicles with crumple zone lengths of 0.1 m, 0.5 m, and 1.0 m, from left to right.

Example student annotations are shown on graphs below.



Images generated using CODAP (https://codap.concord.org/), developed at the Concord Consortium



Images generated using CODAP (https://codap.concord.org/), developed at the Concord Consortium

2. Write and support your claim.
    a. Write your claim that answers the question: What design of crumple zone length will result in increased safety during a collision?

See rubric below.

b. Use evidence from multiple graphs to support your claim.

See rubric below.

Rubric for question 2

	Foundational understanding	Linked understanding	Organized understanding
3-D elements	Look for: • Make a claim that the design of crumple zones affects safety. (CCC: 2.3)	Look for: • Make a claim that connects longer design characteristics of the crumple zone length and increased safety. (SEP: 4.6; CCC: 2.3) • Use evidence from one crash test dummy graph to connect increased safety to lower forces or increased time to stop, but does not make connections across multiple graphs or to the vehicle graphs. (SEP: 4.6; 5.2; DCI: PS2.A.1)	Look for: • Use the graphs to connect the increased time for the vehicle to stop to the increased time for the crash test dummy to stop. (SEP: 4.6; DCI: PS2.A.1) • Use the patterns in the graphs to identify that differences in time and force are relevant to the impact of length of crumple zone on the changes in velocity. (SEP: 4.6; CCC: 1.3; DCI: PS2.A.1) • Make a claim that connects longer design characteristics of the crumple zone length and increased safety in a collision. (SEP: 4.6; CCC: 2.3; DCI: PS2.A.1) • Support the claim by describing the relationship between crumple zone length, the changes in velocity of the vehicle and dummy, and the forces acting on the vehicle and dummy. (SEP: 5.2; DCI: PS2.A.1) • Use patterns in the graphs to support their claim about improving safety. (SEP: 4.6, 5.2; CCC: 1.3, 2.3)
Example	A longer design of the crumple zone results in increased safety.	A longer design of the crumple zone results in increased safety. The top graph shows that when the crash test dummy took longer to stop, it	A longer design of the crumple zone results in increased safety. This is supported by the graphs because the peak force experienced by the dummy was the smallest (about 21 kN) when the length of the crumple zone was the longest (1.0 m). This is

	We can see that longer crumple zone lengths result in an increase in the likelihood of survival.	experienced lower forces, and this happened when the length was longer.	because the shorter crumple zone designs resulted in the crumple zone completely deforming. When the crumple zone deformed completely, the force on the vehicle jumped up to a higher force (3,000 kN). When this happened, the vehicle stopped in a shorter amount of time, which meant the crash test dummy also stopped in a shorter amount of time.
Feedback and what to do	*Linking* While some students might include evidence from the Likelihood of survival vs. Crumple zone length graph, encourage them to use evidence from the following graphs: ● Vehicle velocity vs. time ● Force on vehicle vs. time ● Dummy velocity vs. time ● Force on dummy vs. time	*Organizing* Support students in connecting different graphs in their claim. Use some of the following prompts: ● *How do the changes in velocity of the vehicle influence the changes in velocity of the dummy?* ● *How do the changes in velocity of the vehicle influence the changes in the forces acting on the dummy over time?*	*Extending* Ask students to consider whether increasing the velocity of the vehicle at the moment of a collision will affect the role of the crumple zone length to provide safety.

Classroom-level guidance for what to do next

If three-quarters or more of students provide expected responses	Provide individual feedback to students who are showing Linking and Organizing understanding.
If between half and three-quarters of students provided expected responses	Pair students up at random to discuss their thinking about the prompts. There is sufficient knowledge in the room that peers can support one another's learning. Following the pair strategy, students can be invited to share their thoughts. Teachers can listen in on the conversations and choose and sequence which students who have the expected understanding to share with the class.

If less than half the students provide expected responses	Analyze the assessment items for which pieces of understanding are missing to review or reteach before moving into Lesson 12. Guide students through their Progress Trackers to review what they have done together and identify gaps in learning. Re-teaching can take the form of making sense of the data students are analyzing during day 2. One approach that could be helpful is to engage in public sensemaking using a "think aloud" approach as you make connections between different graphs.

The approach outlined above is adapted from:

- Debarger, A. H., Choppin, J., Beauvineau, Y., & Moorthy, S. (2013). Designing for productive adaptations of curriculum interventions. *Teachers College Record*, *115*(14), 298-319.