NEXT GENERATION SCIENCE STANDARDS
For States, By States

HS-PS2-3

Students who demonstrate understanding can:

HS-PS2-3. **Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.*** [Clarification Statement: Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute.] [*Assessment Boundary: Assessment is limited to qualitative evaluations and/or algebraic manipulations.*]

The performance expectation above was developed using the following elements from *A Framework for K-12 Science Education*:

Science and Engineering Practices

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

- Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects.

Disciplinary Core Ideas

PS2.A: Forces and Motion

- 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.

ETS1.A: Defining and Delimiting an Engineering Problem

- Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. *(secondary)*

ETS1.C: Optimizing the Design Solution

- Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed. *(secondary)*

Crosscutting Concepts

Cause and Effect

- Systems can be designed to cause a desired effect.

Observable features of the student performance by the end of the course:			
1	Using scientific knowledge to generate the design solution		
	a	Students design a device that minimizes the force on a macroscopic object during a collision. In the design, students:	
		i.	Incorporate the concept that for a given change in momentum, force in the direction of the change in momentum is decreased by increasing the time interval of the collision ($F\Delta t = m\Delta v$); and
		ii.	Explicitly make use of the principle above so that the device has the desired effect of reducing the net force applied to the object by extending the time the force is applied to the object during the collision.
	b	In the design plan, students describe the scientific rationale for their choice of materials and for the structure of the device.	
2	Describing criteria and constraints, including quantification when appropriate		

	a	Students describe and quantify (when appropriate) the criteria and constraints, along with the tradeoffs implicit in these design solutions. Examples of constraints to be considered are cost, mass, the maximum force applied to the object, and requirements set by society for widely used collision-mitigation devices (e.g., seatbelts, football helmets).
3	Evaluating potential solutions	
	a	Students systematically evaluate the proposed device design or design solution, including describing the rationales for the design and comparing the design to the list of criteria and constraints.
	b	Students test and evaluate the device based on its ability to minimize the force on the test object during a collision. Students identify any unanticipated effects or design performance issues that the device exhibits.
4	Refining and/or optimizing the design solution	
	a	Students use the test results to improve the device performance by extending the impact time, reducing the device mass, and/or considering cost-benefit analysis.