

HS-PS3-3

Students who demonstrate understanding can:

- HS-PS3-3.** Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.* [Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.] [Assessment Boundary: Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.]

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

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<p>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.</p> <ul style="list-style-type: none"> Design, evaluate, and/or refine a solution to a complex real-world problem based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. 	<p>PS3.A: Definitions of Energy</p> <ul style="list-style-type: none"> At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. <p>PS3.D: Energy in Chemical Processes</p> <ul style="list-style-type: none"> Although energy cannot be destroyed, it can be converted to less useful forms — for example, to thermal energy in the surrounding environment. <p>ETS1.A: Defining and Delimiting an Engineering Problem</p> <ul style="list-style-type: none"> 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. (<i>secondary</i>) 	<p>Energy and Matter</p> <ul style="list-style-type: none"> Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. <p>-----</p> <p>Connections to Engineering, Technology, and Applications of Science</p> <p>Influence of Science, Engineering and Technology on Society and the Natural World</p> <ul style="list-style-type: none"> Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.

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 converts one form of energy into another form of energy.
	b Students develop a plan for the device in which they:
	i. Identify what scientific principles provide the basis for the energy conversion design;
	ii. Identify the forms of energy that will be converted from one form to another in the designed system;
	iii. Identify losses of energy by the design system to the surrounding environment;
	iv. Describe the scientific rationale for choices of materials and structure of the device, including how student-generated evidence influenced the design; and
	v. Describe that this device is an example of how the application of scientific knowledge and engineering design can increase benefits for modern civilization while decreasing costs and risk.
2	Describing criteria and constraints, including quantification when appropriate

	a	Students describe and quantify (when appropriate) prioritized criteria and constraints for the design of the device, along with the tradeoffs implicit in these design solutions. Examples of constraints to be considered are cost and efficiency of energy conversion.
3	Evaluating potential solutions	
	a	Students build and test the device according to the plan.
	b	Students systematically and quantitatively evaluate the performance of the device against the criteria and constraints.
4	Refining and/or optimizing the design solution	
	a	Students use the results of the tests to improve the device performance by increasing the efficiency of energy conversion, keeping in mind the criteria and constraints, and noting any modifications in tradeoffs.