*Unless otherwise specified, "descriptions" referenced in the evidence statements could include but are not limited to written, oral, pictorial, and kinesthetic descriptions.*

# MS-PS3-3 Energy

Students who demonstrate understanding can:

**MS-PS3-3.** **Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.*** [Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.] [*Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.*]

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

## Science and Engineering Practices

**Constructing Explanations and Designing Solutions**

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

- Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system.

## Disciplinary Core Ideas

**PS3.A: Definitions of Energy**

- Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.

**PS3.B: Conservation of Energy and Energy Transfer**

- Energy is spontaneously transferred out of hotter regions or objects and into colder ones.

**ETS1.A: Defining and Delimiting an Engineering Problem**

- The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions.*(secondary)*

**ETS1.B: Developing Possible Solutions**

- A solution needs to be tested, and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. *(secondary)*

## Crosscutting Concepts

**Energy and Matter**

- The transfer of energy can be tracked as energy flows through a designed or natural system.

## Observable features of the student performance by the end of the course:

| | | | |
|---|---|---|---|
| 1 | Using scientific knowledge to generate design solutions | | |
| | a | Given a problem to solve that requires either minimizing or maximizing thermal energy transfer, students design and build a solution to the problem. In the designs, students: | |
| | | i. | Identify that thermal energy is transferred from hotter objects to colder objects. |
| | | ii. | Describe* different types of materials used in the design solution and their properties (e.g., thickness, heat conductivity, reflectivity) and how these materials will be used to minimize or maximize thermal energy transfer. |
| | | iii. | Specify how the device will solve the problem. |
| 2 | Describing* criteria and constraints, including quantification when appropriate | | |
| | a | Students describe* the given criteria and constraints that will be taken into account in the design solution: | |
| | | i. | Students describe* criteria, including: |

| | | |
|---|---|---|
| | | 1. The minimum or maximum temperature difference that the device is required to maintain. |
| | | 2. The amount of time that the device is required to maintain this difference. |
| | | 3. Whether the device is intended to maximize or minimize the transfer of thermal energy. |
| | | ii. Students describe* constraints, which may include: |
| | | 1. Materials. |
| | | 2. Safety. |
| | | 3. Time. |
| | | 4. Cost. |
| 3 | Evaluating potential solutions | |
| | a | Students test the device to determine its ability to maximize or minimize the flow of thermal energy, using the rate of temperature change as a measure of success. |
| | b | Students use their knowledge of thermal energy transfer and the results of the testing to evaluate the design systematically against the criteria and constraints. |