

## Performance Task

### 12.4 Applications of Thermodynamics: Heat Engines, Heat Pumps, and Refrigerators 29.

You have been tasked to design and construct a thermometer that works on the principle of thermal expansion. There are four materials available for you to test, each of which will find use under different sets of conditions and temperature ranges:

#### Materials

- Four sample materials with similar mass or volume: copper, steel, water, and alcohol (ethanol or isopropanol)
- Oven or similar heating source
- Instrument (e.g., meter ruler, Vernier calipers, or micrometer) for measuring changes in dimension
- Balance for measuring mass

#### Procedure

1. Design a safe experiment to analyze the thermal expansion properties of each material.
2. Write down the materials needed for your experiment and the procedure you will follow. Make sure that you include every detail so that the experiment can be repeated by others.
3. Select an appropriate material to measure temperature over a predecided temperature range, and give reasons for your choice.
4. Calibrate your instrument to measure temperature changes accurately.
  - a. Which physical quantities are affected by temperature change and thermal expansion?
  - b. How do such properties as specific heat and thermal conductivity affect the use of each material as a thermometer?
  - c. Does a change of phase take place for any of the tested materials over the temperature range to be examined?
  - d. What are your independent and dependent variables for this series of tests? Which variables need to be controlled in the experiment?
  - e. What are your sources of error?
  - f. Can all the tested materials be used effectively in the same ranges of temperature? Which applications might be suitable for one or more of the tested substances but not the others?

## Teacher Support

**Teacher Support** This performance task supports the following:

NGSS 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.

- a. Alcohol and water can be used effectively in a temperature range between 0 °C and 100 °C. Copper and steel do not expand greatly at these temperatures. The experimental design needs to take this into account.
- b. During thermal expansion, the entire volume of the substance changes, with proportional expansion or contraction occurring in each dimension. Student designs should take this into account; if possible, students should design a means by which all but one dimension is constrained so that temperature may be related directly to linear change (i.e., expansion or contraction in one dimension only).