The Cobb family of Fremont is looking at ways to decrease their home water and energy usage. Their current electric hot-water heater raises the water temperature to 140°F, which requires 0.20 kWh/gallon at a cost of $0.10/kWh. Each person in the family of four showers once a day for an average of 10 minutes per shower. The shower has a flow rate of 5.0 gallons per minute.

(a) Calculate the following. Be sure to show all your work and include units with your answers.

(i) The total amount of water that the family uses per year for taking showers (2 points—1 point for correct set-up and 1 point for correct answer with units)

\[
10 \text{ minutes/day} \times 5 \text{ gallons/minute} \times 365 \text{ days/year} \times 4 \text{ (people)} = 73,000 \text{ gallons/year}
\]

(73,000 gallons also acceptable due to usage defined as per year)

(ii) The annual cost of the electricity for the family showers, assuming that 2.5 gallons per minute of the water used is from the hot-water heater (2 points—1 point for correct set-up and 1 point for correct answer with units)

\[
73,000 \text{ gallons/year} \div 2 = 36,500 \text{ gallons of hot water per year}
\]

\[
36,500 \text{ gallons/year} \times 0.20 \text{ kWh/gallon} \times $0.10/\text{kWh} = $730/\text{year}
\]

($730 also acceptable due to cost defined as per annum)

(b) The family is considering replacing their current hot-water heater with a new energy-efficient hot-water heater that costs $1,000 and uses half the energy that their current hot-water heater uses. How many days would it take for the new hot-water heater to recover the $1,000 initial cost? (2 points—1 point for correct set-up and 1 point for correct answer with units)

Old bill for electricity = $730/year = $2/day

New bill for electricity = $730/2 = $365/year

\[
$365/\text{yr} \div 365 \text{ day/year} = $1/\text{day} = \text{new cost per day}
\]

Old cost = $2/day, new cost = $1/day

Savings old – new = $1/day

Days to pay off initial cost = cost \div $saved/day = $1,000 \div $1/\text{day} = 1,000 days

(1,000 also acceptable due to days stated in the question)

With the old heater they were spending $2/day for hot water for showers; with the new heater they would spend $1/day for hot water for showers. Therefore, the savings is $1/day, and they would recover the $1,000 cost of the new hot-water heater in 1,000 days.

Savings calculation alone:

\[
0.2\text{kWh/gallon} \div 2 = 0.10\text{kWh/gallon saved}
\]

\[
0.10\text{kWh/gallon} \times 2.5 \text{ gallons/minute} \times 10 \text{ minutes/person} \times 4 \text{ people} \times $0.10/\text{kWh} = $1/\text{day}
\]

\[
$1,000 \div $1/\text{day} = 1,000 \text{ days}
\]

Another way of looking at it:

The new hot-water heater would mean a savings of $365 per year. $1,000 \div $365/\text{year} = 2.74 years

2.74 years \times 365 \text{ days/year} = 1,000 \text{ days} (1,000 also acceptable due to days given in problem)
Question 2 (continued)

(c) Describe TWO practical measures that the family could take that would reduce their overall water use at home. (2 points total—1 point for each measure)

Valid answers to this question include:

- Reduce the length of daily showers
- Shower less frequently
- Install low-flow shower heads and/or toilets
- Make sure all water leaks are fixed
- Don’t let water run while brushing teeth
- Run the dishwasher or washing machine only when fully loaded
- Use a water-efficient appliance
- Hand washing dishes uses less water than running a dishwasher
- Use of paper plates and plastic silverware; not using the dishwasher
- Use plants outside that require little watering/only water on alternate days/use drip irrigation systems/moisture sensing sprinklers
- Sweeping driveway/sidewalks versus washing with water
- Don’t let water run while washing the car
- Wash the car less frequently
- Use a car wash
- Reuse of water—gray water, bucket in shower to later water plants, rain barrel, etc.

(d) Describe TWO conservation measures (other than reducing hot water use) that the family could take to reduce the total amount of energy that they use at home. (2 points—1 point for each measure)

Valid answers to this question include:

- Turn off electric appliances when no one is in the room
- Turn off lights in daylight hours
- Replace incandescent light bulbs with fluorescents
- Increase insulation
- Set thermostat to higher temperatures in the summer and lower temperatures in the winter
- Use an automatic thermostat that lowers/raises temperatures when no one is in the house
- Replace appliances with energy-efficient appliances
- Caulk and/or weather-strip exterior doors and windows
- Replace single-pane windows with double-pane or other more energy-efficient windows
- Open windows/run fans rather than running air-conditioning
- Use sweaters/blankets rather than running heater
- Reduce usage by not using appliances—hand wash vs. dishwasher
- Unplug appliances when not in use.
- Line dry clothing instead of using dryer
- Lower thermostat of water heater
- Add insulation blanket to the hot water heater
- Purchase more energy-efficient water heater
- Use of passive solar with description
2. The Cobb family of Fremont is looking at ways to decrease their home water and energy usage. Their current
electric hot-water heater raises the water temperature to 140°F, which requires 0.20 kWh/gallon at a cost of
$0.10/kWh. Each person in the family of four showers once a day for an average of 10 minutes per shower.
The shower has a flow rate of 5.0 gallons per minute.

(a) Calculate the following. Be sure to show all your work and include units with your answers.
   (i) The total amount of water that the family uses per year for taking showers
   (ii) The annual cost of the electricity for the family showers, assuming that 2.5 gallons per minute of the
       water used is from the hot-water heater

(b) The family is considering replacing their current hot-water heater with a new energy-efficient hot-water
    heater that costs $1,000 and uses half the energy that their current hot-water heater uses. How many days
    would it take for the new hot-water heater to recover the $1,000 initial cost?

(c) Describe TWO practical measures that the family could take that would reduce their overall water use at
    home.

(d) Describe TWO conservation measures (other than reducing hot water use) that the family could take to
    reduce the total amount of energy that they use at home.

\[ \text{2a. (i) } 4 \text{ people} \times \frac{10 \text{ min/day}}{\text{person}} \times \frac{365 \text{ days}}{\text{year}} \times \frac{5 \text{ gallons H}_2\text{O}}{\text{min}} = 73000 \text{ gal. H}_2\text{O per year} \]

\[ \text{2a. (ii)} \frac{73000 \text{ gal H}_2\text{O}}{\text{year}} \times \frac{0.2 \text{ kWh}}{\text{gal}} \times \frac{\$0.10}{\text{kWh}} \times \frac{2.5 \text{ gal/min (from hot water heater)}}{\text{50 gal/min (total water)}} = \$170 \text{ per year} \]

\[ \text{b. } \frac{73000 \text{ gal H}_2\text{O}}{\text{year}} \times \frac{0.1 \text{ kWh}}{\text{gal}} \times \frac{\$0.10}{\text{kWh}} \times \frac{2.5 \text{ gal/min (from hot water heater)}}{\text{50 gal/min (total water)}} = \$365 \text{ per year} \]

\[ \text{Since originally the cost of energy was } \$2 \text{ per day, the cost has now decreased} \]
\[ \text{by } \$1 \text{ per day. Therefore, it would take } 1000 \text{ days to recover the } \$1000 \text{ initial cost.} \]

\[ \text{c. They could take shorter showers;} \]
\[ \text{d. They could turn off the water from the faucet when they're brushing their teeth;} \]
\[ \text{They could turn off unused lights;} \]
\[ \text{They could turn off the computer when it's not being used;} \]
\[ \text{They could turn off the sprinklers when it is raining outside.} \]
2. The Cobb family of Fremont is looking at ways to decrease their home water and energy usage. Their current electric hot-water heater raises the water temperature to 140°F, which requires 0.20 kWh/gallon at a cost of $0.10/kWh. Each person in the family of four showers once a day for an average of 10 minutes per shower. The shower has a flow rate of 5.0 gallons per minute.

(a) Calculate the following. Be sure to show all your work and include units with your answers.

(i) The total amount of water that the family uses per year for taking showers

(ii) The annual cost of the electricity for the family showers, assuming that 2.5 gallons per minute of the water used is from the hot-water heater

(b) The family is considering replacing their current hot-water heater with a new energy-efficient hot-water heater that costs $1,000 and uses half the energy that their current hot-water heater uses. How many days would it take for the new hot-water heater to recover the $1,000 initial cost?

(c) Describe TWO practical measures that the family could take that would reduce their overall water use at home.

(d) Describe TWO conservation measures (other than reducing hot water use) that the family could take to reduce the total amount of energy that they use at home.

\[
\text{(i) } 10 \text{ min} \times 5 \text{ gal/min} \times 4 \text{ people} = 200 \text{ gal. (per day)} \\
200 \text{ gal} \times 365 \text{ days} = 73000 \text{ gal/year} \\
\text{Annual Total water use} = 73000 \text{ gal/year} \\
\text{(ii) } 10 \text{ min} \times 2.5 \text{ gal/min} \times 0.2 \text{ kWh/gal} = 5 \text{kWh (per day)} \\
5 \text{kWh} \times $0.10/\text{kWh} \times 365 \text{ days} = $152.5 \\
\text{Annual Total cost} = $152.5
\]
b) 10 min x 2.5 gal/min x 0.1 kWh/gal = 2.5 kWh (per day) 
2.5 kWh x $0.10/kWh = $0.25 (per day) 
$1000 ÷ $0.25/day = 4000 days 
Time to recover initial cost = 4000 days

c) To reduce a family's overall water consumption, a practical measure is to water the lawn less and more efficiently. Watering the lawn at night is more efficient than the day because it reduces evaporation. (Watering the lawn depending on the climate) twice or three times a week reduces water use greatly. Also, since most household water is consumed by flushing the toilet, a low-flush toilet could be purchased to cut back on this use of water.

d) To reduce a family's energy consumption, better insulation of their home would help. Much of the energy consumed goes to controlling a home's climate, and super insulating the home prevents leaks and requires less energy and heat to maintain a comfortable temperature. The family could also stop using incandescent light bulbs as they are far less efficient than fluorescent lights and require more energy to put out light.
2. The Cobb family of Fremont is looking at ways to decrease their home water and energy usage. Their current electric hot-water heater raises the water temperature to 140°F, which requires 0.20 kWh/gallon at a cost of $0.10/kWh. Each person in the family of four showers once a day for an average of 10 minutes per shower. The shower has a flow rate of 5.0 gallons per minute.

(a) Calculate the following. Be sure to show all your work and include units with your answers.

(i) The total amount of water that the family uses per year for taking showers

(ii) The annual cost of the electricity for the family showers, assuming that 2.5 gallons per minute of the water used is from the hot-water heater

(b) The family is considering replacing their current hot-water heater with a new energy-efficient hot-water heater that costs $1,000 and uses half the energy that their current hot-water heater uses. How many days would it take for the new hot-water heater to recover the $1,000 initial cost?

(c) Describe TWO practical measures that the family could take that would reduce their overall water use at home.

(d) Describe TWO conservation measures (other than reducing hot water use) that the family could take to reduce the total amount of energy that they use at home.

\[
\begin{array}{|c|c|c|c|}
\hline
\text{(A)(i)} & 10 \text{kWh} & 10 \text{min} & 0.1 \text{kWh} \\
\hline
\text{(A)(ii)} & 100 \text{gal.} & 10 \text{min} & 500 \text{gal.} \\
\hline
\end{array}
\]

\[
10 \text{kWh/gallon per year}
\]

\[
\begin{array}{|c|}
\hline
\text{(B)} \text{ It would take half a year for the new hot-water heater to recover the } \$1,000 \text{ initial cost?}
\hline
\end{array}
\]

\[
\begin{array}{|c|}
\hline
\text{(C) Two practical measures that the family could take that would reduce their overall water use at home is to one, reduce the}
\hline
\text{amount of time they take showers and two, take a shower every}
\hline
\end{array}
\]
(d) Two conservatory measures that the family could take to reduce the total amount of energy that they use at home is take out leisure electronics such as TVs and microwaves and to take shorter showers especially in the summer.
Overview

The purpose of this data-based question was to assess the students’ ability to analyze information, to calculate water use and electricity costs, and to calculate the cost savings from replacing an old water heater with a more efficient one. It also measured students’ ability to recognize home water conservation and energy conservation measures.

Sample: 2A
Score: 10

Part (a): Two points were earned in (a)(i): 1 point for correctly calculating the number of gallons used per year for showering, and 1 point for the correct answer with units. Two points were earned in (a)(ii): 1 point for correctly calculating the annual cost in dollars per year for electricity in the setup, and 1 point for the correct answer with units.

Part (b): Two points were earned: 1 point for correctly calculating the savings per year from the new hot-water heater in the setup, and 1 point for the correct answer.

Part (c): Two points were earned for water conservation measures: 1 point for “shorter showers” (reducing the length), and 1 point for turning “off the sprinklers when it is raining outside.”

Part (d): Two points were earned for energy conservation measures: 1 point for turning “off unused lights,” and 1 point for turning “off the computer when it’s not being used.”

Sample: 2B
Score: 6

Part (a): Two points were earned in (a)(i): 1 point for correctly calculating the number of gallons used per year for showering, and 1 point for the correct answer with units. No points were earned in (a)(ii). The student incorrectly calculates the annual cost in dollars per year for electricity in the setup, and no point was earned for an incorrect answer.

Part (b): No points were earned. The student incorrectly calculates the savings per year from the new hot-water heater in the setup by neglecting to account for the four people in the family. No point was earned for an incorrect answer.

Part (c): Two points were earned for water conservation measures: 1 point for watering “the lawn less” and “at night” to reduce evaporation losses, and 1 point for purchasing “a low-flush [flow] toilet.”

Part (d): Two points were earned for energy conservation measures: 1 point for better insulation, and 1 point for using more energy-efficient fluorescent lights rather than incandescent lights.

Sample: 2C
Score: 3

Part (a): No points were earned in (a)(i). The student incorrectly calculates the number of gallons used per year for showering, and no point was earned for the incorrect answer. No points were earned in (a)(ii). The student incorrectly calculates the annual cost in dollars per year for electricity in the setup, and no point was earned for an incorrect answer.
Question 2 (continued)

Part (b): No points were earned. The student does not show a setup, and no point was earned for an incorrect answer.

Part (c): Two points were earned for water conservation measures: 1 point for reducing “the amount of time they take showers,” and 1 point for taking “a shower every other day.”

Part (d): One point was earned for energy conservation measures (for not using electronic appliances). The cooler showers did not earn a point, because the question states that conservation measures must be other than from reducing hot water use. The remainder is an insufficient description involving energy conservation.