Science Objectives

- Students will observe and analyze thermal energy transfer between metals and water.
- Students will understand the relationship between heat, mass, specific heat, and temperature change in a system.

Vocabulary

- energy
- thermal energy
- heat
- temperature
- thermal equilibrium
- specific heat
- metal
- mass

About the Lesson

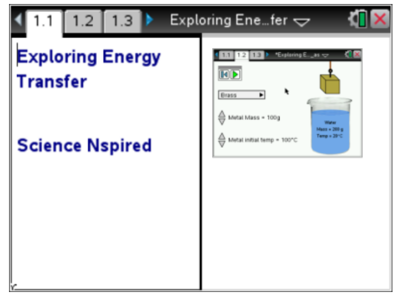
- In this lesson, students will:
  - Measure the time it takes for two objects to come to thermal equilibrium.
  - Calculate the heat gained or lost by an object using mass, specific heat, and change in temperature.
  - Understand how the energy gained or lost by an object relates to the change in temperature of the object.

TI-Nspire™ Navigator™

- Send out the *Exploring_Energy_Transfer.tns* file.
- Monitor student progress using Class Capture.
- Use Live Presenter to spotlight student answers.

Activity Materials

- Compatible TI Technologies: TI- Nspire™ CX Handhelds, TI-Nspire™ Apps for iPad®, TI-Nspire™ Software



Tech Tips:

- This activity includes screen captures taken from the TI-Nspire CX handheld. It is also appropriate for use with the TI-Nspire family of products including TI-Nspire software and TI-Nspire App. Slight variations to these directions may be required if using other technologies besides the handheld.
- Watch for additional Tech Tips throughout the activity for the specific technology you are using.
- Access free tutorials at http://education.ti.com/calculators/pd/US/Online-Learning/Tutorials

Lesson Files:

Student Activity

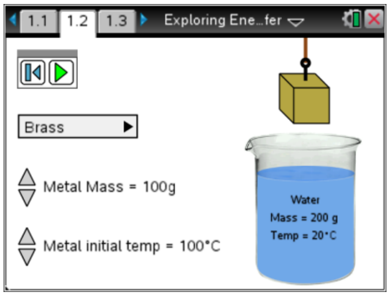
- Exploring_Energy_Transfer_Student.doc
- Exploring_Energy_Transfer_Student.pdf

TI-Nspire document

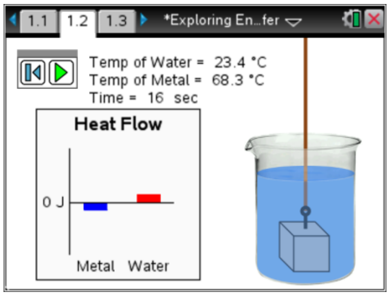
- Exploring_Energy_Transfer.tns

Discussion Points and Possible Answers

Move to Pages 1.2 - 1.4.



1. Have students use the drop down menu to select any metal of their choice. (Alternatively, you may assign specific metals for different students or groups to explore.) Have students use the up and down arrows to adjust the metal cube so that it has a mass of 10 g and a temperature of 100°C. They should record the type of metal and the initial temperatures of the metal cube and water in the table on their student activity sheets.



2. Have students select the Play button and observe the changes in temperature of the metal block and the water. Once the block and water have come to thermal equilibrium, have students observe the spreadsheet and graph on pages 1.3 and 1.4.

3. Students should record the final temperatures of the water and metal in the table. They should also record the time it took for both objects to come to thermal equilibrium. (To determine the precise time it takes both objects to come to equilibrium, students should observe the time in the spreadsheet when both temperatures first become equal.)

4. Have students return to Page 1.2 and repeat steps 1 - 3 for the different masses listed in the table. Be sure that they use same metal each time and keep the initial temperature to set to 100°C.

Tech Tip: To access the Directions again, select menu or **Document Tools ( ) > Matter Conservation > Directions.**

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Metal: Brass

(Note: Data tables will be different for students exploring a different metal type.)

Initial Metal Mass (g)	Initial Metal Temp (°C)	Final Metal Temp (°C)	Metal Change in Temp (°C)	Initial Water Temp (°C)	Final Water Temp (°C)	Water Change in Temp (°C)	Time to reach equilibrium (s)
10	100	20.3615	-79.6385	20	20.3615	0.3615	17.4
20	100	20.7197	-79.2803	20	20.7197	0.7197	35.3
30	100	21.0747	-78.9253	20	21.0747	1.0747	53.8
40	100	21.4266	-78.5734	20	21.4266	1.4266	67.8
50	100	21.7753	-78.2247	20	21.7753	1.7753	86.4
60	100	22.1209	-77.8791	20	22.1209	2.1209	112.1
70	100	22.4635	-77.5365	20	22.4635	2.4635	131.8
80	100	22.8031	-77.1969	20	22.8031	2.8031	150.7
90	100	23.1398	-76.8602	20	23.1398	3.1398	151
100	100	23.4735	-76.5265	20	23.4735	3.4735	170.8

Move to Pages 1.5 - 1.6.

Have students answer question 1 - 2 in the .tns file, the activity sheet, or both.

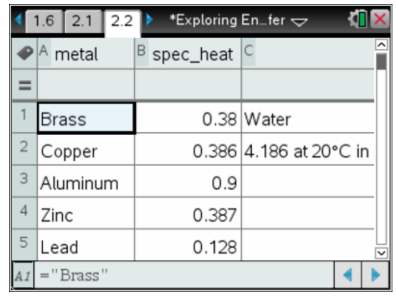
Q1. How does the mass of the metal cube affect the time it takes for the metal and water to reach thermal equilibrium?

Answer: A. As the mass of the cube increases, the time it takes to reach equilibrium increases.

Q2. Calculate the change in temperature of the metal and water for each mass in the table. How does the change in temperature of the water compare with the change in temperature of the metal? (Note that a negative temperature change means that the object decreased in temperature.)

Sample Answer: The metal always decreases in temperature while the water always increases in temperature; The change in temperature of the metal is rather large, while the change in temperature of the water is always very small.

Move to Pages 2.1 - 2.2.



5. Have students read the information on pages 2.1 and 2.2. The heat energy gained or lost by an object is given by the following equation:

   $\Delta Q = mass * Specific\ Heat * \Delta T$

   where ΔQ is heat energy gained or lost by the object and ΔT is the change in temperature of the object.

6. Have students calculate the heat energy gained or lost by the brass cube and water masses given in the table. (They will need to use some of the data from the first table they completed in their student activity sheets.)

Metal: Brass

Metal Mass (g)	Specific Heat of Metal (J/g°C)	Metal Change in Temp (°C) = ΔT	ΔQ for Metal (J)	Water Mass (g)	Specific Heat of Water (J/g°C)	Water Change in Temp (°C) = ΔT	ΔQ for Water (J)
10	0.38	-79.6385	-302.6	200	4.186	0.3615	302.6
40	0.38	-78.5734	-1194.3	200	4.186	1.4266	1194.3
70	0.38	-77.5365	-2062.5	200	4.186	2.4635	2062.4
100	0.38	-76.5265	-2908.0	200	4.186	3.4735	2908.0

Move to Pages 2.3 - 2.7.

Have students answer questions 3 - 7 in the .tns file, the activity sheet, or both.

Q3. Compare the calculated values of "ΔQ for Metal" and "ΔQ for Water" in your table. What do you notice about these quantities?

Sample Answer: The quantities are equal but opposite.

Q4. Based on the results of your calculations, which of the following can you conclude?

Answer: B. The heat energy gained by the water is equal to the heat energy lost by the metal.

Q5. 10 g of water and 10 g of copper are placed under a heat lamp. Each object absorbs an equal amount of heat energy. Which object will increase most in temperature?

Answer: B. copper

Q6. 10 g of zinc and 10 g of alluminum are placed under a heat lamp. Each object absorbs an equal amount of heat energy. Which object will increase most in temperature?

Answer: A. zinc

Q7. If the two objects in questions 5 and 6 absorb the same amount of heat energy, why is it that the temperature of one object increases more than the other?

Sample Answer: Even though the objects absorb the same amount of heat energy, they have different specific heats. This means that each object's temperature will change by a different amount.

TI-Nspire Navigator Opportunities

Make various students who are testing different metals a Live Presenter to illustrate how each metal's temperature changes at a different rate when dropped in the water. Throughout the activity, monitor student progress. At the end of the activity, collect the .tns file and save to Portfolio.

Wrap Up

Students should compose a lab report, which includes their data, analysis, and a discussion of the results of their test. Students may choose to use the TI-Nspire™ Student Edition software to convert their .tns files to PublishView Documents.

Assessment

- Use the questions in the Nspire document as Quick Polls during the lesson as needed.
- The questions in the Nspire document can be Self-Check, so students can check their answers.
- Summative assessment could consist of questions/problems on the chapter test or a performance assessment involving the creation of a poster illustrating energy and temperature changes of various metals explored in the simulation.