General Physics 1 12 Q2 Mod6 Temperatureand Heat Version 2

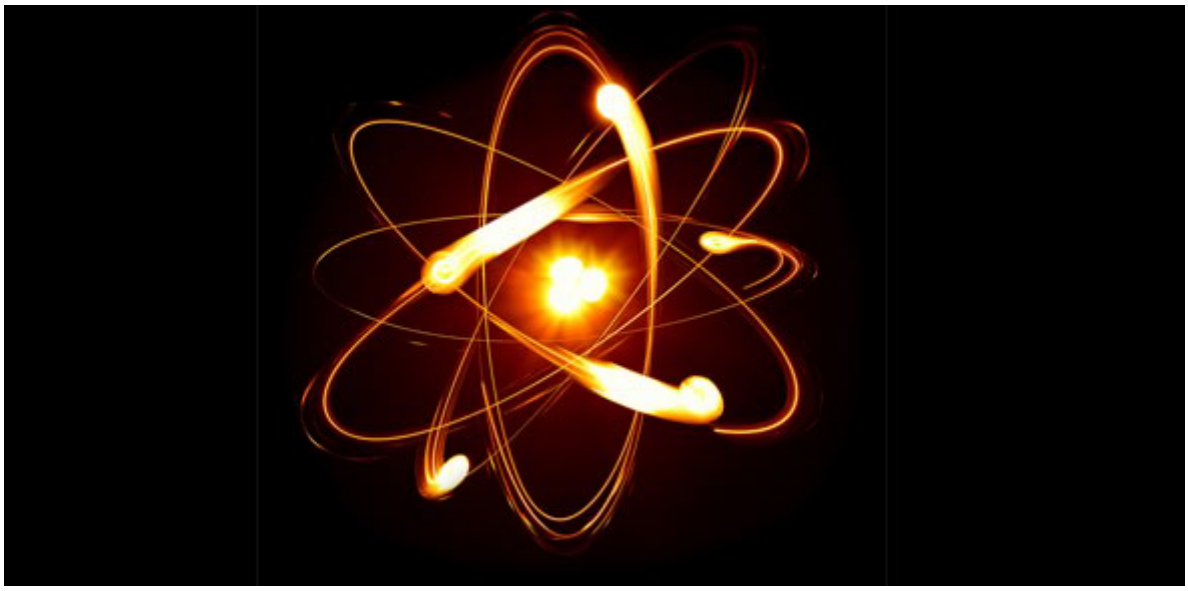
Principles in Teaching 1 (Salazar Colleges of Science and Institute of Technology)

Senior High School

General Physics 1

Quarter 2 - Module 6

Temperature and Heat



Department of Education ● Republic of the Philippines

General Physics1 -Grade 12
Alternative Delivery Mode Self-Learning Module
Quarter 2 - Module 6: Temperature and Heat
First Edition, 2020

Published by the Department of Education – Division of Cagayan de Oro
Schools Division Superintendent: Dr. Cherry Mae L. Limbaco, CESO V

Development Team of the Module

Writer: Blossom Jane M. Bañares

Reviewer:

Illustrator and Layout Artist:

Management Team
Chairperson: Cherry Mae L. Limbaco, PhD, CESO V
Schools Division Superintendent

Co-Chairpersons: Alicia E. Anghay, PhD, CESE
Asst. Schools Division Superintendent

Members
Lorebina C. Carrasco, OIC-CID Chief
Jean S. Macasero, EPS-Science
Joel D. Potane, LRMDS Manager
Lanie O. Signo, Librarian II
Gemma Pajayon, PDO II

Printed in the Philippines by
Department of Education – Bureau of Learning Resources (DepEd-BLR)
Office Address: Fr. William F. Masterson Ave Upper Balulang Cagayan de Oro
Telefax: (08822)855-0048
E-mail Address: cagayandeoro.city@deped.gov.ph

Senior High School

General Physics 1

Quarter 2 - Module 6

Temperature and Heat

This instructional material was collaboratively developed and reviewed by educators from public and private schools, colleges, and or/universities. We encourage teachers and other education stakeholders to email their feedback, comments, and recommendations to the Department of Education at action@ deped.gov.ph.

We value your feedback and recommendations.

Department of Education ● Republic of the Philippines

Table of Contents

What This Module is About

This module demonstrates your understanding the concept of Zeroth law of Thermodynamics and temperature measurement and skills in solving thermal expansion of solids and liquids.

This module has three (3) lessons:

- **Lesson 1 – Zeroth Law of Thermodynamics and Temperature measurements**
- **Lesson 2 – Thermal Expansion**
- **Lesson 3 – Heat and Heat Capacity**

What I Need to Know

At the end of this module, you should be able to:

1. explain the connection between the Zeroth Law of Thermodynamics, temperature, thermal equilibrium, and temperature skills. **(STEM_GP12TH-IIG-49)**
2. convert temperature and temperature differences in the following scales: Fahrenheit, Celsius, Kelvin. **(STEM_GP12TH-IIG-50)**
3. define coefficient of thermal expansion and coefficient of volume expansion. **(STEM_GP12TH-IIG-51)**
4. calculate the volume or length changes of solids due to changes in temperatures. **(STEM_GP12TH-IIG-52)**
5. solve problems involving temperature, thermal expansion, heat capacity, heat transfer, and thermal equilibrium in contexts such as, but not limited to, the design of bridges and train rails using steel, relative severity of steam burns and water burns, thermal insulation, sizes of stars and surface temperatures of plantes. **(STEM_GP12TH-IIG-53)**

How to Learn from This Module

Below, are guide steps for you to attain the learning competencies in going about the module.

1. Read the lessons and follow the instructions carefully.

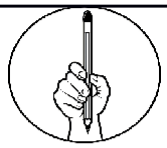
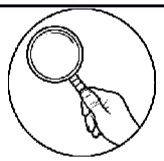
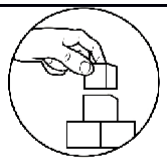
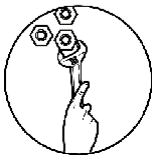
2. Take the pretest to determine how much you know about the content. A multiple-choice test was provided for you. Be honest.

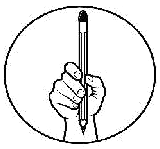
3. Perform all the activities diligently to help you understand the topic.

4. Take the assessment test (post-test) at the end of the module.

Icons of this Module

Here are the Icons used as your guide in every part of the lesson:

	What I Need to Know	This part contains learning objectives that are set for you to learn as you go along the module.
	What I know	This is an assessment as to your level of knowledge to the subject matter at hand, meant specifically to gauge prior related knowledge
	What's In	This part connects previous lesson with that of the current one.
	What's New	An introduction of the new lesson through various activities, before it will be presented to you
	What is It	These are discussions of the activities as a way to deepen your discovery and understanding of the concept.
	What's More	These are follow-up activities that are intended for you to practice further in order to master the competencies.
	What I Have Learned	Activities designed to process what you have learned from the lesson
	What I can do	These are tasks that are designed to showcase your skills and knowledge gained, and applied into real-life concerns and situations.



What I Know

Pre-Test:

Multiple Choice. Answer the question that follows. Choose the best answer from the given choices.

1. Which of the following statement is NOT true about Law of thermodynamics?

   a. Heat flows from an object with low temperature to an object with higher temperature

   b. An object with higher temperature will gain energies from an object with lower temperature when they are in direct contact.

   c. An object with lower temperature will lose its energies when in direct contact with an object with a higher temperature.

   d. Thermal equilibrium of two objects with different temperature will attain at some point.

2. Why the electric wire that is connecting in the post outside a little bit saggy and not tightly tied?

   a. To make space for the other wires to easily connect

   b. So that it will not break once the wire will expand

   c. So that it will not hard for the line men to reach it.

   d. So that it will not be tangled by the other wires.

3. What is 10

   a. 280 b. 281 c. 282 d. 283

4. How much heat is needed to raise the temperature of 2 kg of water 5K?

   a. 41800J b. 42800 J C. 43800J D. 44800J

5. Why the sand is much hotter compared to water in the beach if they are exposed with the same source which is the sun?

   a. The water has higher specific heat compared to the sand

   b. The sand has higher specific heat compared to the water

   c. The sand is directly exposed to sun compared to the water

   d. The water is directly exposed to sun compared to the sand

II. Crossword Puzzle:

Vertical

2. As the thermal energy of a substance increase, its particles spread out and the substance expand.

3. Meaning of the greek word “therme”

4. The field of science concerned with describing heat and its relationship with energy is

6. freezing point of Celsius

7. A device used to measure temperature

9. The most common temperature scale that is used.

10. the ideal temperature scale used in the laboratory experiments.

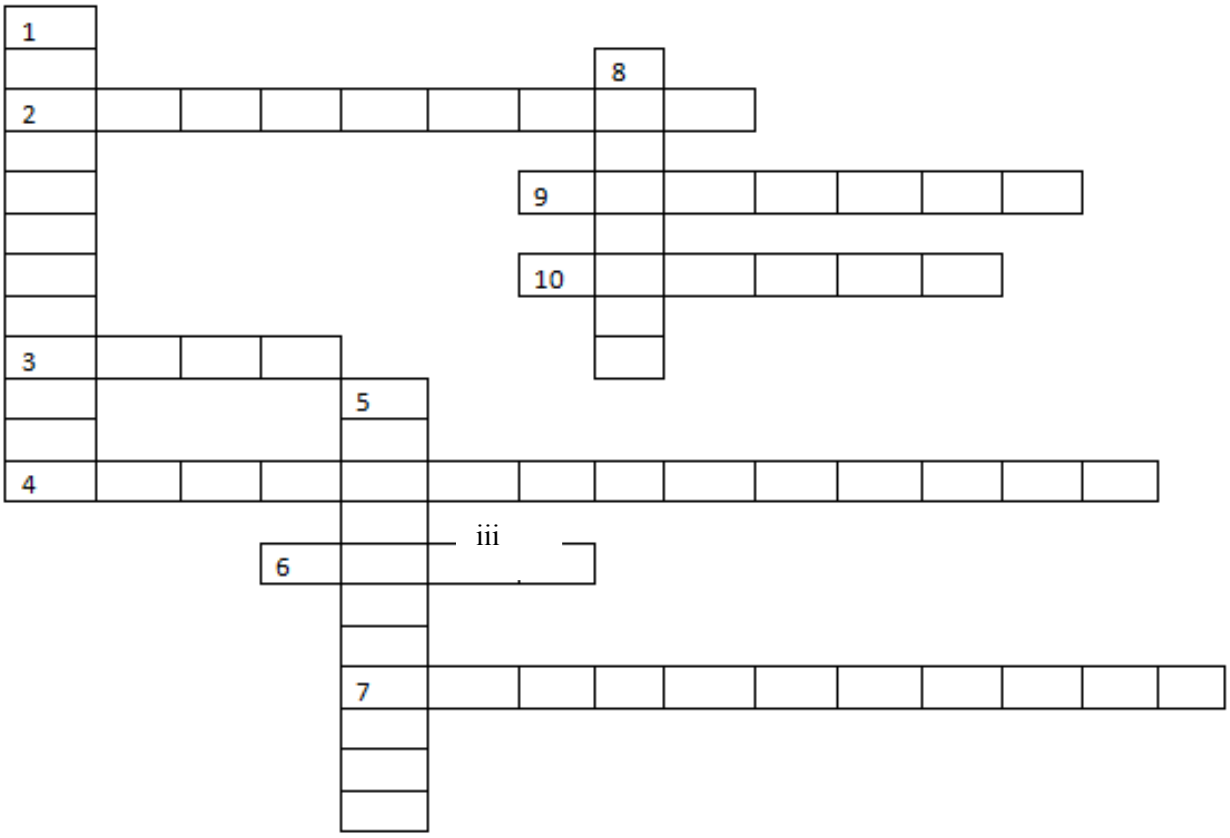
iii

Horizontal:

1. The amount of energy required to raise the temperature of one kilogram of a substance by one kelvin

5. It is the measure of the hotness and coldness of a substance

8. The meaning of the Greek work “dynamicos”



Lesson 1

Temperature and Zeroth Law of Thermodynamics

What I Need to Know

We always associate the word temperature for something that is hot or cold wherein a body that feels hot has a higher temperature and a body that feels cold has a lower temperature. But sometimes our senses can mislead us for example a two object: a metal cup and plastic tray was removed in the freezer when you touch these two objects the metal cup is much colder compared to the plastic tray eventhough they came from the same freezer. What we'd like may be a reliable and reproducible method for measuring the relative hotness or coldness of objects instead of the speed of energy transfer.

In this module you will understand the connection between the Zeroth Law of Thermodynamics, temperature, thermal equilibrium, and temperature skills.

What's New

Activity 1.1 Measure Me!

Objective: at the end of the activity you should be able to:

1. understand the concepts of heat, temperature and internal energy
2. convert between temperature scales

Materials:

1 thermometer, 2 Styrofoam cup, boiling water, tap water, calculator

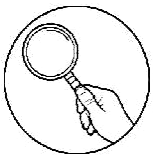
Caution: Be careful with the HOT WATER

Procedure:

1. Put the two Styrofoam cup side by side label it as A and B.
2. Pour half cup of boiling water into the cup A and B. In the cup B pour a little amount of tap water
3. Measure the temperatures of the Cup A and B.
4. Leave the cups for 10 minutes. After 10 minutes measure the temperature again.

Guide Questions. Write your answer on a separate sheet of paper.

1. What is the temperature of the cup A and cup B in the first reading? What is the temperature of the water in cup A and B after 10 minutes? Do they have the same temperature reading?
2. What does temperature reading tells you?
3. Convert the temperature of cup A into ºF and K.



What Is It

We are familiar with the ideas such as heat and temperature in our daily lives. But what are the underlying physical phenomena underlying these concepts? The field of science concerned with describing heat and its relationship with energy is called ***thermodynamics.***

The word thermodynamics comes from the Greek words ***therme,*** meaning "***heat***" and ***dynamicos*** meaning "***movement***". It is not just the study of heat and work alone but instead it is the study of the dynamics and behavior of energy and its manifestations. It is said that energy is the only thing that keeps things going which is very true. Thermodynamics is considered be one of the most important parts of our daily life.

Zeroth Law of thermodynamics

When two objects at different initial temperature reaches the same temperature at some point they are now in thermal equilibrium. We can discover an important property of thermal equilibrium by considering three systems, A, B, and C, that initially are not in thermal equilibrium (Fig.1). We enclosed it with an ideal insulating box so that they cannot interact with anything except each other.

FIGURE 1

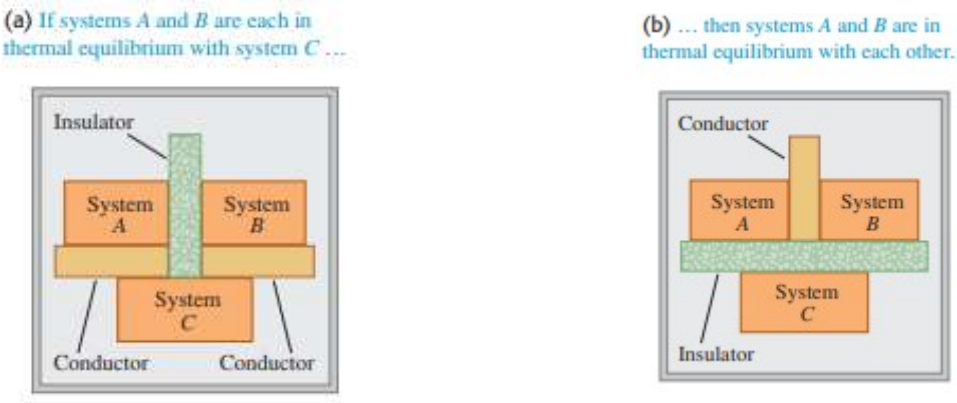
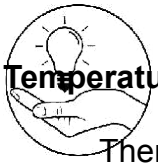


Figure 1. Closed System . If system C is initially in thermal equilibrium with both system A and system B, then system A and system B are also in thermal equilibrium with each other this is called the **zeroth law of thermodynamics**. Temperature is the property that determines whether an object is in thermal equilibrium or not.

Note: Two systems are in thermal equilibrium if and only if they have the same temperature.



Temperature Scales

Thermometer is a device used to measure temperature of a system. The three common scales that is used for measuring temperature are the Fahrenheit, Celsius and Kelvin Scales.

1. **Celsius temperature scale** – it is the common scale that is usually used to measure temperature. In Celsius the 0º Celsius is the freezing point and 100ºC is the boiling point.

2. **Fahrenheit Scale** - This scale sets the temperature of the ice point at 32°F and the temperature of the steam point at 212°F.

$$T_{\mathrm{F}} = \frac{9}{5}T_{\mathrm{C}} + 32°\mathrm{F}$$

3. **Kelvin Scale** – any temperature on the Kelvin scale can be change into Celsius by adding 273 on it.

Example:

1. Convert 50ºC into ºF
   Equation:
   $$T_{\mathrm{F}} = \frac{9}{5}T_{\mathrm{C}} + 32°\mathrm{F}$$

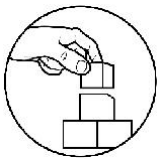
   Solution:

2. Convert 40

What's More

Exercises: Write you answer on a separate clean sheet of paper.
Direction: Convert the following:

1.
2.
3.
4.
5.



What I Have Learned

I. Direction: Read and analyze the question. Write your answers in a separate paper.

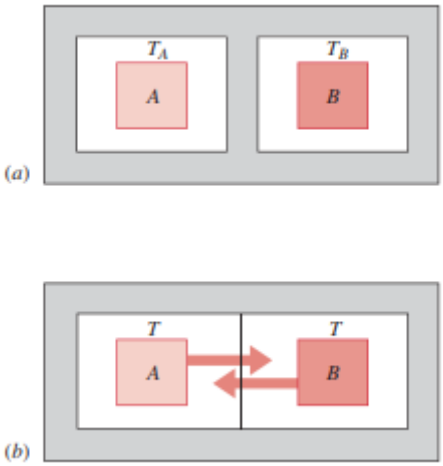


Figure A. the objects A and B are inside a closed system(isolated with the outside environment) wherein they are separated with adiabatic wall (no flow of energy). Figure B. is separated with diathermic wall (permits the flow of energy).

Question:

1. Explain how the Zeroth law of thermodynamics in the figure A and B.

_____
_____
_____
_____

II. Solve the following. (Show your solutions)

1.

2 Thermal Expansion

What's In

You have learned in lesson 1, connection between the Zeroth Law of Thermodynamics, temperature, thermal equilibrium, and temperature skills and how to solve the temperature scales.

In this module, you will learn how thermal expansions work especially in roads, houses and etc.

What I Need to Know

In this lesson, you are expected to:

1. Explain the importance of thermal and volume expansion
2. Solve the volume or length changes of solids due to changes in temperatures.

What's New

I. Direction: Analyze each questions and answer the following.

1. You have a difficulty in opening the metal lid of your jam jar. What will you choose: a) dip it in a cold water:; b) dip it in a hot water? Why?

2. Why are the wire that is connected in the posts outside are lightly saggy not tightly tied by the line man?

3. What do you think is the reason why there are always a small gaps in the road even in a tiled floor?

What Is It

Have you experienced a difficulty in opening a tightly metal lid jar? There is an easy way in opening it just dip the metal lid in a hot water and wait for a couple of second and you can now easily open it. This is due to ***thermal expansion*** of the materials especially metals and liquids.

Thermal Expansion

Thermal expansion occurs once an object is heated the molecules tends to get excited and move faster and take up more space that tends the materials to expand or contract.

Thermal expansion plays an important role in numerous engineering applications like buildings, concrete highways, railroad tracks, brick walls, and bridges to compensate for dimensional changes that occur as the temperature changes. Figure 1 shows a toothlike seams which can be seen in some bridges. This toothlike seams is called as expansion joint this intentionally made by the engineers since this expansion joints move together as the bridge expands in hot weather and contracts in a cold

FIGURE 1. EXPANSION JOINTS

LINEAR EXPANSION

Suppose a metal rod of material has a length at some initial temperature ,When the temperature changes by the length changes by Experiments show that if is not too large (say, less than 100 ºC or so), is directly proportional to (Fig. 2a). If two rods made of the same material have the same temperature change, but one is twice as long as the other, then the change in its length is also twice as great. Therefore must also be proportional to (Fig. 2b). Introducing a proportionality constant (which is different for different materials), we may express these relationships in an equation:

(Linear thermal expansion)

If a body has length at a temperature , then its length L at a temperature is,

$$L = L_0 + \Delta L = L_0 + \alpha L_0 \Delta T = L_0(1 + \alpha \Delta T)$$

The constant ***α*** which describes the thermal expansion properties of a particular material, is called the **coefficient of linear expansion**. The units of ***α*** are K^{-1} or C^{-1}.

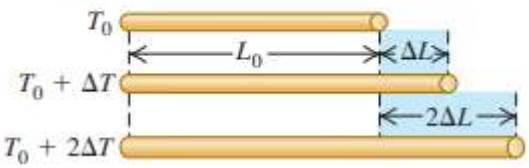


FIGURE 2a

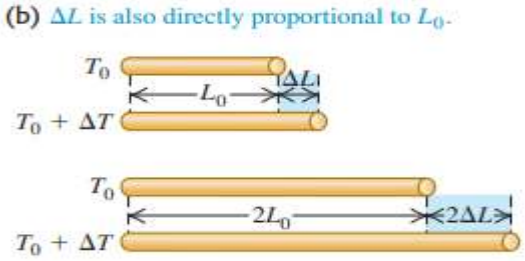


FIGURE 2b

TABLE 1. COEFFICIENT OF LINEAR EXPANSION

Material	$\alpha\ [K^{-1}$ or $(C°)^{-1}]$
Aluminum	2.4×10^{-5}
Brass	2.0×10^{-5}
Copper	1.7×10^{-5}
Glass	$0.4–0.9 \times 10^{-5}$
Invar (nickel–iron alloy)	0.09×10^{-5}
Quartz (fused)	0.04×10^{-5}
Steel	1.2×10^{-5}

VOLUME EXPANSION

The change in volume is directly proportional to the initial volume and to the change in temperature according to the relationship

where is the average coefficient of volume expansion of the substance. For a solid materials, the average coefficient of volume expansion is three times the average linear expansion coefficient:

TABLE 2: COEFFICENT OF VOLUME EXPANSION

Solids	$\beta\ [K^{-1}$ or $(C°)^{-1}]$	Liquids	$\beta\ [K^{-1}$ or $(C°)^{-1}]$
Aluminum	7.2×10^{-5}	Ethanol	75×10^{-5}
Brass	6.0×10^{-5}	Carbon disulfide	115×10^{-5}
Copper	5.1×10^{-5}	Glycerin	49×10^{-5}
Glass	$1.2–2.7 \times 10^{-5}$	Mercury	18×10^{-5}
Invar	0.27×10^{-5}		
Quartz (fused)	0.12×10^{-5}		
Steel	3.6×10^{-5}		

SAMPLE PROBLEMS:

Linear expansion

1. A segment of a steel railroad track has a length of 50 m when the temperature is 20°C. What is its length at 50 ^{0}C?
   Given:

   Solution:

If the track is 50 m long at 20°C, its length at 50°C is 50.0165 m

Volume Expansion

1. A 100 cm^3 glass flask is filled with alcohol at 10°C. How much ethanol overflows when the temperature of the system is raised at 80 °C? α = 0.40 x $10^{-5}\ K^{-1}$

Get the volume of the glass(soild) by using the
Solve for the overflowed alcohol:

What I Have Learned

I. DIRECTION: Solve and analyze the following problems. Show the necessary solutions.

1. The newly constructed bridge in your town is a steel arch bridge 600 m in length. How much does the total length of the roadway decking change between temperature extremes of 30°C and 50.0°C?

2. A copper wire has essentially no sag between poles 50 m apart on a winter day when the temperature is 10°C. How much longer is the copper wire on a summer day when T = 35.0°C?

3. What is the volume of a aluminum ball at 10°C if its volume at 160°C is 300cm^3 ?

II. Direction: Read and analyze the question:
Metal lids on glass jars can often be loosened by running hot water over them. How is this possible?

_____
_____
_____
_____
_____
_____
.

3 Heat and Heat Capacity

What's In

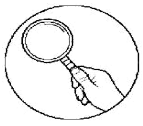
In your past lesson, you learned that heat flows from a substance with a higher temperature to a substance with a lower temperature. If the two substance transfer energies one substance will lose it energies and the other substance will gain energies from the other substance.

In this module, you will learn the heat capacity and its application in our daily lives.

What I Need to Know

In this lesson, you are expected to

1. Explain specific heat
2. Solve problems involving specific heat



What Is It

Have you ever wonder why the pizza sauce is hotter than the crust even though they are removed from the oven at the same time? This is because of the specific heat of the cheese and the crust. The cheese has a high specific heat compared to crust meaning the cheese gives more heat faster than the crust. This is also the reason why the sand is hotter compared to water in the beach even though they are exposed by the same source which is the sun.

The **heat capacity** of a particular sample is defined as the amount of energy needed to raise the temperature of that sample by 1°C. From this definition, we see that if energy Q produces a change in the temperature of a sample, then

The **specific heat** c of a substance is the heat capacity per unit mass. Therefore, if energy Q transfers to a sample of a substance with mass m and the temperature of the sample changes by , the specific heat of the substance is

Or we can rewrite it as,

Where Q = heat
m- mass of the substance

TABLE 1. SPECIFIC HEATS OF SOME SUBSTANCE AT 25 AND ATMOSPHERIC PRESSURE

Specific Heats of Some Substances at 25°C and Atmospheric Pressure

Substance	Specific Heat *c* J/kg · °C	Specific Heat *c* cal/g · °C	Substance	Specific Heat *c* J/kg · °C	Specific Heat *c* cal/g · °C
Elemental solids			*Other solids*		
Aluminum	900	0.215	Brass	380	0.092
Beryllium	1 830	0.436	Glass	837	0.200
Cadmium	230	0.055	Ice (−5°C)	2 090	0.50
Copper	387	0.092 4	Marble	860	0.21
Germanium	322	0.077	Wood	1 700	0.41
Gold	129	0.030 8	*Liquids*		
Iron	448	0.107	Alcohol (ethyl)	2 400	0.58
Lead	128	0.030 5	Mercury	140	0.033
Silicon	703	0.168	Water (15°C)	4 186	1.00
Silver	234	0.056	*Gas*		
			Steam (100°C)	2 010	0.48

Sample Problem:

1. How much heat is needed to raise the temperature of a 3kg of aluminum 8K?
   Step 1: Given: m = 3 kg;
   Step 2: Equation:

   Step 3 : Solution:

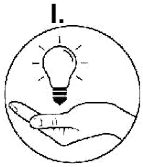
2. What is the temperature of the 11 f 0.6 kg of alcohol at 60 is added to 0.5 kg alcohol at 20in polysterene cup?
   Step 1: Given:

Step 2:

Step 3 : Solution:

What I Have Learned

I.



Direction: Solve and analyze the following problems:

1. How much energy is lost by 20 kg copper if it is cooled from 50
2. A 20 kg metal rod is heated 100°C with 2000 J of energy. What is the specific heat of the metal?

Assessment: (Post-Test)

Multiple Choice. Select the letter of the best answer from among the given choices.

I. Direction: Multiple choices. Select the letters that correspond to the best answer.

1. Which of the following statement is NOT true about Law of thermodynamics?

   a. Heat flows from an object with low temperature to an object with higher temperature

   b. An object with higher temperature will gain energies from an object with lower temperature when they are in direct contact.

   c. An object with lower temperature will lose its energies when in direct contact with an object with a higher temperature.

   d. Thermal equilibrium of two objects with different temperature will attain at some point.

2. Why the electric wire that is connecting in the post outside a little bit saggy and not tightly tied?

   a. To make space for the other wires to easily connect

   b. So that it will not break once the wire will expand

   c. So that it will not hard for the line men to reach it.

   d. So that it will not be tangled by the other wires.

3. What is 10

   a. 280 b. 281 c. 282 d. 283

4. How much heat is needed to raise the temperature of 2 kg of water 5K?

   a. 41800J b. 42800 J C. 43800J D. 44800J

5. Why the sand is much hotter compared to water in the beach if they are exposed with the same source which is the sun?

   a. The water has higher specific heat compared to the sand

   b. The sand has higher specific heat compared to the water

   c. The sand is directly exposed to sun compared to the water

   d. The water is directly exposed to sun compared to the sand

II. Crossword Puzzle:

Vertical

2. As the thermal energy of a substance increase, its particles spread out and the substance expand.

3. Meaning of the greek word “therme”

4. The area of science concerned with describing heat and its relationship with energy is

6. freezing point of Celsius

7. A device used to measure temperature

9. The most common temperature scale that is used.

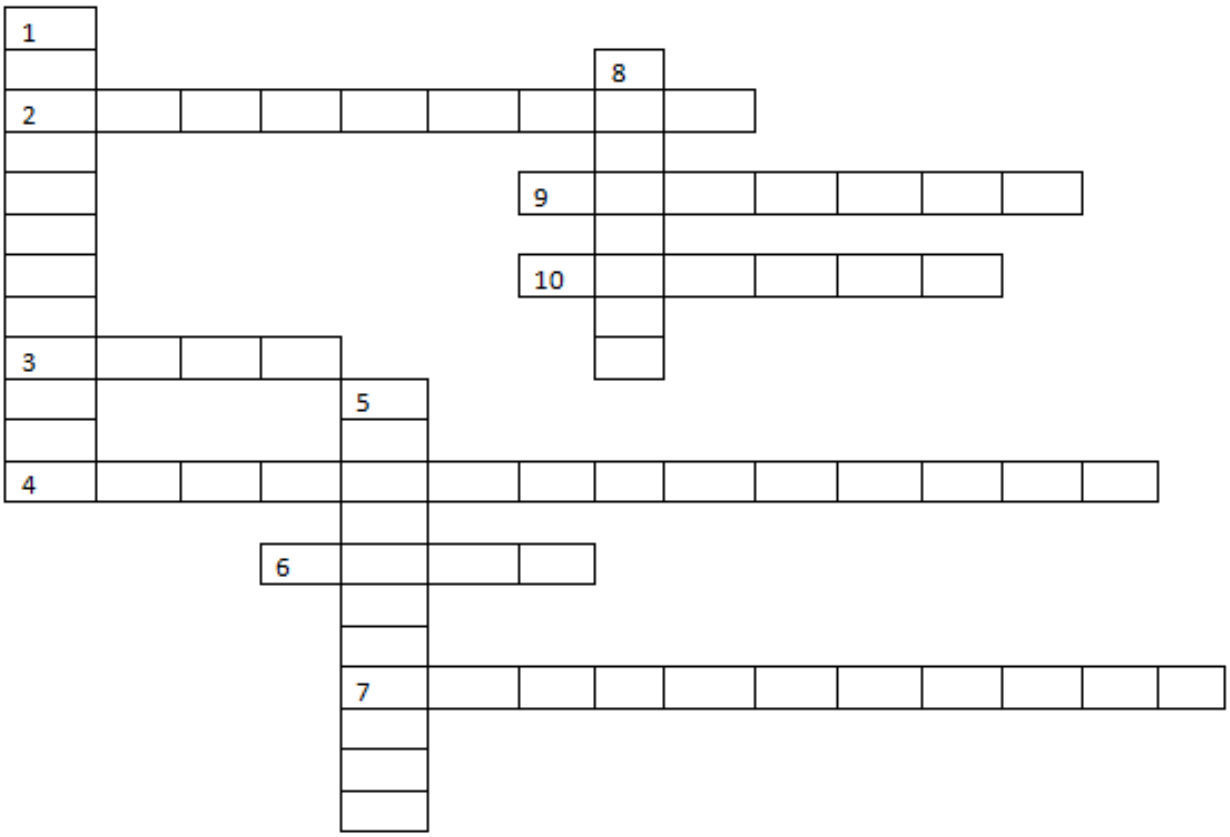
10. the ideal temperature scale used in the laboratory experiments.

Horizontal:

1. The amount of energy required to raise the temperature of one kilogram of a substance by one kelvin

5. It is the measure of the hotness and coldness of a substance

8. The meaning of the Greek work “dynamicos”



Answer key:

Pre-test

1. A
2. B
3. D
4. A
5. B

II. Crossword

1. Specific heat
2. Expansion
3. Heat
4. Thermodynamics
5. Temperature
6. Zero
7. Thermometer
8. Movement
9. Celsius
10. Kelvin

Lesson 1:

What's more:

1. 122
2. -3.88
3. 260
4. 278
5. 353

Lesson 2:

What I have learned:

Lesson 3:

1. – 154800 J
2.

Post-test

1. A
2. B
3. D
4. A
5. B

I. Crossword

1. Specific heat
2. Expansion
3. Heat
4. Thermodynamics
5. Zero
6. Thermometer
7. Movement
8. Celsius
9. Kelvin
10.

1. 600.14 m
2. 50.02 m

References

Serway, R., 1996. Physics. Philadelphia [etc.]: Saunders.
Halliday, D., Resnick, R., Halliday, D. and Walker, J., n.d. *Fundamentals Of Physics*.
Serway / Jewett., n.d. *Physics For Scientists & Engineers With Modern Physics*.
Cengage 2014.

For inquiries and feedback, please write or call:

Department of Education – Bureau of Learning Resources (DepEd-BLR)

DepEd Division of Cagayan de Oro City
Fr. William F. Masterson Ave Upper Balulang Cagayan de Oro
Telefax: ((08822)855-0048
E-mail Address: cagayandeoro.city@deped.gov.ph