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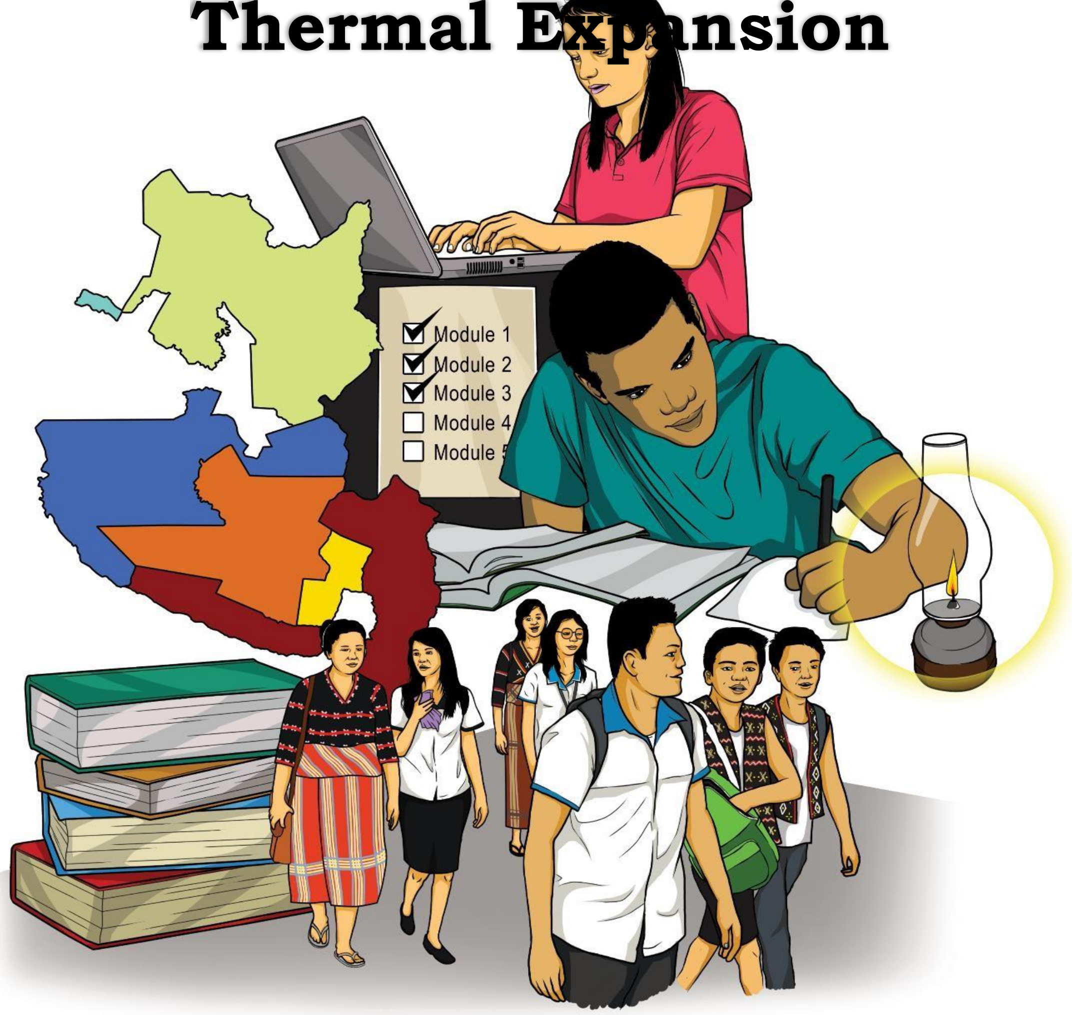
DEPARTMENT OF EDUCATION

General Physics 1

Quarter 2 - Module 9
Thermal Expansion



SELF-LEARNING MODULE

SLM

DEPARTMENT OF EDUCATION - SOCCSKSARGEN

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Physics- Grade 12
Self-Learning Module (SLM)
Quarter 2 – Module 9: Thermal Expansion
First Edition, 2020

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12

General Physics 1

Quarter 2 – Module 9:
Thermal Expansion

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Introductory Message

For the facilitator:

Welcome to the **General Physics - 12** Self-Learning Module (SLM) on **Thermal Expansion!**

This module was collaboratively designed, developed and reviewed by educators both from public and private institutions to assist you, the teacher or facilitator in helping the learners meet the standards set by the K to 12 Curriculum while overcoming their personal, social, and economic constraints in schooling.

This learning resource hopes to engage the learners into guided and independent learning activities at their own pace and time. Furthermore, this also aims to help learners acquire the needed 21st century skills while taking into consideration their needs and circumstances.

In addition to the material in the main text, you will also see this box in the body of the module:

Notes to the Teacher

This contains helpful tips or strategies that will help you in guiding the learners.

As a facilitator you are expected to orient the learners on how to use this module. You also need to keep track of the learners' progress while allowing them to manage their own learning. Furthermore, you are expected to encourage and assist the learners as they do the tasks included in the module.

For the learner:

Welcome to the **General Physics - 12** Self-Learning Module (SLM) on **Thermal Expansion!**

The hand is one of the most symbolized part of the human body. It is often used to depict skill, action and purpose. Through our hands we may learn, create and accomplish. Hence, the hand in this learning resource signifies that you as a learner is capable and empowered to successfully achieve the relevant competencies and skills at your own pace and time. Your academic success lies in your own hands!

This module was designed to provide you with fun and meaningful opportunities for guided and independent learning at your own pace and time. You will be enabled to process the contents of the learning resource while being an active learner.

This module has the following parts and corresponding icons:

What I Need to Know	This will give you an idea of the skills or competencies you are expected to learn in the module.
What I Know	This part includes an activity that aims to check what you already know about the lesson to take. If you get all the answers correct (100%), you may decide to skip this module.
What's In	This is a brief drill or review to help you link the current lesson with the previous one.
What's New	In this portion, the new lesson will be introduced to you in various ways such as a story, a song, a poem, a problem opener, an activity or a situation.
What is It	This section provides a brief discussion of the lesson. This aims to help you discover and understand new concepts and skills.
What's More	This comprises activities for independent practice to solidify your understanding and skills of the topic. You may check the answers to the exercises using the Answer Key at the end of the module.
What I Have Learned	This includes questions or blank sentence/paragraph to be filled in to process what you learned from the lesson.
What I Can Do	This section provides an activity which will help you transfer your new knowledge or skill into real life situations or concerns.
Assessment	This is a task which aims to evaluate your level of mastery in achieving the learning competency.

Additional Activities	In this portion, another activity will be given to you to enrich your knowledge or skill of the lesson learned. This also tends retention of learned concepts.
Answer Key	This contains answers to all activities in the module.

At the end of this module you will also find:

References	This is a list of all sources used in developing this module.

The following are some reminders in using this module:

1. Use the module with care. Do not put unnecessary mark/s on any part of the module. Use a separate sheet of paper in answering the exercises.
2. Don’t forget to answer *What I Know* before moving on to the other activities included in the module.
3. Read the instruction carefully before doing each task.
4. Observe honesty and integrity in doing the tasks and checking your answers.
5. Finish the task at hand before proceeding to the next.
6. Return this module to your teacher/facilitator once you are through with it.

If you encounter any difficulty in answering the tasks in this module, do not hesitate to consult your teacher or facilitator. Always bear in mind that you are not alone.

We hope that through this material, you will experience meaningful learning and gain deep understanding of the relevant competencies. You can do it!

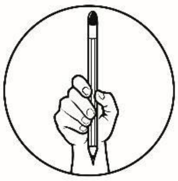
What I Need to Know

This module was designed and written with you in mind. It is here to help you master the nature of Physics. The scope of this module permits it to be used in many different situations, and lets you explore the vast concept of momentum and impulse. The lessons are arranged to follow the standard sequence of the course.

At the end of this module, you will be able to **define coefficient of thermal expansion and coefficient of volume expansion** (STEM_GP12THIIg-51) **and calculate volume or length changes of solids due to changes in temperature** (STEM_GP12THIIg-52).

After going through this module, you are expected to:

1. define coefficient of thermal expansion and coefficient of volume expansion.
2. calculate volume or length changes of solids due to changes in temperature, and;
3. solve problems involving thermal and volume expansion.



What I Know

Multiple Choice. Choose the letter of the best answer. Encircle the letter of your choice.

1. Which of the following is the best definition of thermal expansion? A. Molecules moving faster.
   B. An object never changing in size.
   C. An object in size due to increased temperature.
   D. An object remaining the same size no matter the temperature.

2. If you heat up an object that contains holes and crevices, what happens to those holes?
   A. They remain same size.
   B. They increase in size at the same rate as the object itself.
   C. They increase in size at a rate greater than the object itself.
   D. They decreased in size.

3. Why does running a jar under hot water make it easier to open? A. Because hot things are more malleable.
   B. Because the metal expands into the spaces between the glass threads.
   C. Because the gaps between the threads and the lid get larger as it expands.
   D. Because the gaps between the threads and the lid get smaller as it expands.

4. What is the symbol used for volumetric expansion?
   A. γ B. β C. L D. α

5. A material of length L_1 at temperature $\theta_1 K$ is subjected to a temperature rise of θK. The coefficient of linear expansion of the material αK^{-1}. What is the expansion of the material?
   A. $L_2(1+\alpha\theta)$ B. $L_1\alpha(\theta-\theta_1)$ C. $L_1[1+\alpha(\theta-\theta_1)]$ D. $L_1\alpha$

6. Some iron has a coefficient of linear expansion of $12 \times 10^{-6}K^{-1}$. A 100mm length of iron piping is heated through 20K. How much the pipe extends?
   A. 0.24mm B. 0.024mm C. 2.4mm D. 0.0024mm

7. Which of the following is false?
   A. Gaps need to be left in lengths of railway lines to prevent buckling in hot weather.
   B. Bimetallic strips are used in thermostats, a thermostat being a temperature-operated switch.
   C. As the temperature of water in decreased from 4°C to 0°C contraction occurs.
   D. A change of temperature of 15°C is equivalent to a change of temperature of 15K.

8. What happen to the amplitude of vibration of the atoms or molecules on an object when cooling?
   A. Increases B. Decrease C. Remains same D. Remains constant

9. The volume of a rectangular block of iron at a temperature t_1 is V_1. The temperature is raised to t_2 and the volume to V_2. If the coefficient of linear expansion of iron is α, the volume V_1 is given by:

   A. $V_2[1 + \alpha(t_2 - t_1)]$ B. $1{+}3\alpha V(t22{-}t1)$ C. $3V_2\alpha(t_2 - t_1)$ D. $1{+}\alpha(Vt22{-}t1)$

10. In what conditions does the molecules of a solid vibrate with larger amplitude?
    A. Zero temperature C. Higher temperature
    B. Lower temperature D. Pressure

11. What is the cause in the increase in breadth, length, and thickness of a substance?
    A. Boiling B. Fusion C. Stress D. Thermal expansion

12. A composite rod made of copper ($1.8 \times 10^{-5}K^{-1}$) and steel $\alpha = 1.2 \times 10^{-5}K^{-1}$ is heated. What will happen to the composite rod made of copper and steel after heating?
    A. It shrink. C. It bends with steel on concave side.
    B. It does not expand. D. It bends with copper on concave side

13. In what season does the thermal expansion compensate for gaps that are left in railway?
    A. Rainy season C. Hot season
    B. Winter D. Wind

14. The length of a 100mm bar of metal increases by 0.3mm when subjected to a temperature rise of 100 K. What is the coefficient of linear expansion of linear expansion of the metal?
    A. $3 \times 10^{-3}K^{-1}$ B. $3 \times 10^{-4}K^{-1}$ C. $3 \times 10^{-5}K^{-1}$ D. $3 \times 10^{-6}K^{-1}$

15. If the coefficient of linear expansion is A, the coefficient of superficial expansion is B and the coefficient of cubic expansion is C, which of the following is false?
    A. $C = 3A$ B. $A = {}^{B}$ C. $B\ \frac{3}{2}\ = C$ D. $A = {}^{C}$
    23

Lesson 1 THERMAL EXPANSION *(Volume and Length Changes of Solid)*

Learning Objectives:

1. define coefficient of thermal expansion and coefficient of volume expansion.
2. calculate volume or length changes of solids due to changes in temperature, and;
3. solve problems involving thermal and volume expansion.

What's In

Activity 1. Puzzle in Motion

Given the synonyms and clues of the words, identify the words being presented below. Write your answer on the space provided.

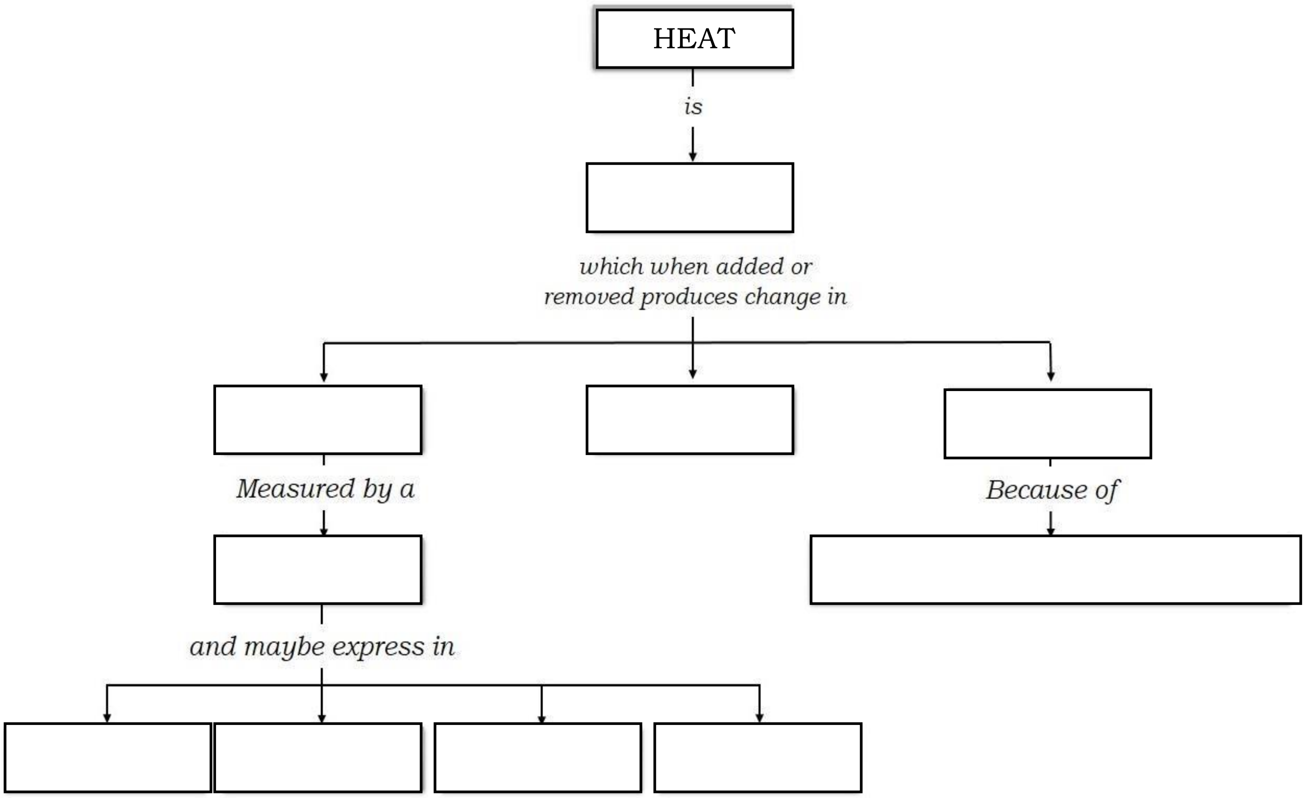
WORDS	SYNONYMS
1. E __ __ __ N __ __ __ __	Increase, Enlargement, Extension
2. __O__ __ __I__ __ __ __T	Constant, Number, Figure
3. __ E__ __ E __ __ __ __ __E	Hotness, Celsius, Fahrenheit
4. __ __ __ __ T__	Distance, Measurement, Height
5. __ __ __ U__ __	Size, Liter, Space

What's New

Activity 2. Concept Box

Fill in the graphic organizer based on the given selection.

THERMAL EXPANSION/CONTRACTION		PHASE	ENERGY
KELVIN	DIMENSION	FAHRENHEIT	TEMPERATURE
CELSIUS	THERMOMETER	RANKINE	



Activity 3. Mix and Match

Answer the following problem below by matching the commonly used symbols in thermal expansion to its specific name. Write the letter of the correct answer on the space provided.

___________ 1. T	**a. Length**
___________ 2. β	**b. Alpha**
___________ 3. L	**c. Volume**
___________ 4. α	**d. Beta**
___________ 5. V	**e. Temperature**

What is It

This module was designed and written with you in mind. It is here to help you master the nature of Physics. The scope of this module permits it to be used in many different situations, and lets you explore the vast concept of momentum and impulse. The lessons are arranged to follow the standard sequence of the course.

Thermal Expansion is the tendency of matter to change it shape, area, and volume in response to a change in temperature.

An increase in temperature implies an increase in the kinetic energy of the individual atoms. In a solid, unlike in a gas, the atoms or molecules are closely packed together, but their kinetic energy (in the form of small, rapid vibrations) pushes neighboring atoms or molecules apart from each other. This neighbor-to-neighbor pushing results in a slightly greater distance, on average, between neighbors, and adds up to a larger size for the whole body. For most substances under ordinary conditions, there is no preferred direction, and an increase in temperature will increase the solid's size by a certain fraction in each dimension.

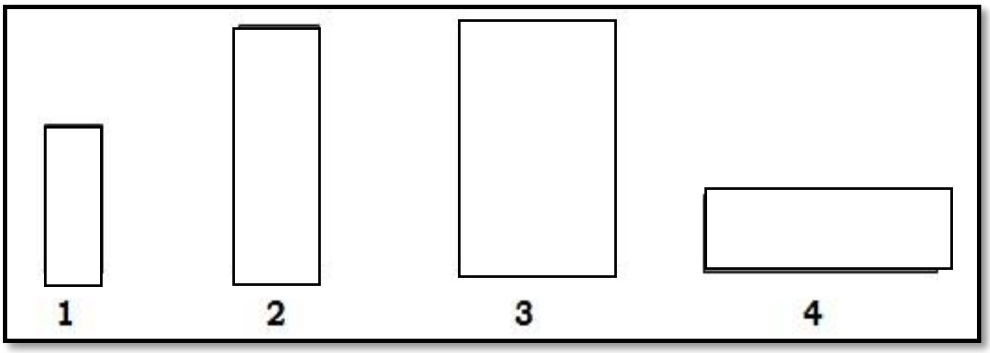
Temperature is a monotonic function of the average molecular kinetic energy of a substance. When a substance is heated, the kinetic energy of its molecules increases. Thus, the molecules begin vibrating/moving more and usually maintain a greater average separation.

Materials which contract with increasing temperature are unusual; this effect is limited in size, and only occur within limited temperature ranges. The relative expansion divided by the change in temperature is called the material's **Coefficient of linear thermal expansion** and generally varies with temperature. When an object is heated or cooled, its length change by an amount proportional to the original length and the change in temperature.

Linear expansion means change in one dimension (length) as opposed to change in volume (volumetric expansion). The change in length measurements of an object due to thermal expansion is related to temperature change by a coefficient of linear thermal expansion.

Activity 4. Metalinearity

The figure below shows four rectangular metal plates, with sides of 1L, 2L, and 3L. They are all made of the same material, and their temperature is to be increased by the same amount. **Rank the plates according to the expected increase in (a) their vertical heights and (b) their areas. Arrange from greatest to least rate of expansion.**



Volume expansion is defined as the increase in the volume of the solid on heating. Remember that volume is equal to the product of length, width and height ***(l* x *w* x *h).***

If all dimensions of a solid expand with temperature, the volume of that solid must also expand. For liquids, volume expansion is the only meaningful expansion parameter.

If the temperature of a solid or liquid whose volume is $\boldsymbol{V}$ and increased by an amount $\Delta\boldsymbol{T}$, the increase in volume is found to be;

$$\Delta \boldsymbol{V} = \boldsymbol{V\beta}\Delta\boldsymbol{T}$$

where β is the **coefficient of volume expansion** of the solid or liquid. The coefficients of volume expansion and linear expansion for a solid are related by $= \boldsymbol{3\alpha}$ **.**

Example:

Suppose an iron bar was heated from 15°C up to 280°C to be molded into a car bumper, what will be its new volume if the coefficient of volume expansion $\boldsymbol{\beta}$ is equal to $36 \times \mathbf{10^{-6}}\boldsymbol{C^{\circ -1}}$?

SOLUTION:

STEP 1: Use the equation for the volume thermal expansion $\Delta\boldsymbol{V} = \boldsymbol{\beta V}\Delta\boldsymbol{T}$ to calculate the change in volume, ΔV. Use the coefficient of volume expansion,β, for iron and note that the change in temperature, ΔT, is 265°C

Given:

$\beta = 36 \times 10^{-6} C^{\circ -1}$

$\Delta T = T_{final} - T_{initial} = 270℃ - 15℃ = \mathbf{255}C^{\circ}$

$V = l \times w \times h = 190cm \times 60cm \times 60cm = \mathbf{684,000}\boldsymbol{cm^3}$

STEP 2: Plug all of known values into the equation to solve for ΔV.

$\Delta V = \beta V \Delta T$

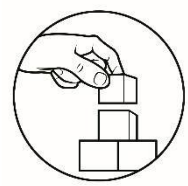
$\Delta V = (\frac{36}{\cancel{C^{\circ}}} \times 10^{-6})\ (\mathbf{600}\boldsymbol{cm^3})(\ \mathbf{255}\cancel{C^{\circ}})$

$\Delta \boldsymbol{V} = \mathbf{5,232.6}\boldsymbol{cm^3}$

Activity 5. Volume Expansion (VolEx)

Calculate the volume expansion of the given material below.

A iron block whose initial temperature 10°C was heated at about 260°C. What will be its new volume if the coefficient of volume expansion β is equal to $36 \times 10^{-6} C^{\circ -1}$?



What's More

Activity 6. Bridge of Contract

Solve the given problem below

The main span of Silway Bridge 1 is 0.06km at its coldest. The bridge is exposed to temperatures ranging forming 15°C to 40°C. What is its change in length between these temperatures? Assume the bridge is made of entirely of steel. ($\alpha = 12 \times 10^{-6}{}^{\circ}C^{-1}$)

What I Have Learned

Activity 7. Thermal Filler

Fill in the blanks to complete the paragraph.

(1) __________ is the tendency of matter to change it shape, area, and volume in response to a change in temperature.

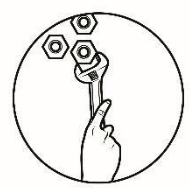
An increase in **(2)** __________ implies an increase in the kinetic energy of the individual atoms. In a solid, unlike in a gas, the atoms or molecules are **(3)** __________**,** but their kinetic energy (in the form of small, rapid vibrations) pushes neighboring atoms or molecules apart from each other. This neighborto-neighbor pushing results in a slightly greater distance, on average, between neighbors, and adds up to a larger size for the whole body.

Materials which **(4)** __________ with increasing temperature are unusual; this effect is limited in size, and only occur within limited temperature ranges. The relative expansion divided by the change in temperature is called the material's **(5)** ______________________________ and generally varies with temperature. When an object is heated or cooled, its length change by an amount **(6)** __________ to the original length and the change in temperature.

(7) __________ means change in one dimension (length) as opposed to change in volume (volumetric expansion). The change in length measurements of an object due to thermal expansion is related to temperature change by a coefficient of linear thermal expansion.

(8) __________ is defined as the increase in the volume of the solid on heating. Remember that volume is equal to the product of **(9)** __________, **(10)** __________ and height.

If all dimensions of a solid expand with temperature, the volume of that solid must also expand. For liquids, volume expansion is the only meaningful expansion parameter.



What I Can Do

Activity 8. Coefficient of Expansion

Direction: Perform the task provided below

An experiment to measure the thermal expansion of a metal bar that has a length of 1 m long at 20°C produced the following results. Answer the following questions.

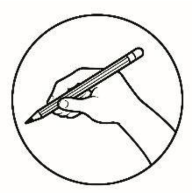
Temperature (°C)	Length (m)
0	0.999620
5	0.999715
10	0.999810
15	0.999905
20	1.000000

Guide Questions:

1. Why some lengths less than 1m while others are greater than 1m?
2. Is the metal bar measures exact 1m long at 20°C? Why?
3. Would you expect to get the same results for the different type of metal?
4. Plot these data.
   What do you notice about the y-axis?
5. The gradient of the graph gives the thermal expansion coefficient of the material. This tells an engineer the change in length in meters that occurs per meter of material initially present per °C change in temperature. What is the gradient of the graph you have just plotted? Give your answer in standard form.

Formula: $gradient(coefficient\ of\ expansion\ (\alpha) = \dfrac{Lfinal-Linitial}{tfinal-tinitial}$;

L = length; t = temperature



Assessment

Multiple Choice. Read and analyze the following questions. Encircle the letter of the correct answer.

1. Which of the following statement is incorrect?
   A. Gaps need to be left in lengths of railway lines to prevent buckling in hot weather.
   B. Bimetallic strips are used in thermostats, a thermostat being a temperature-operated switch.
   C. As the temperature of water in decreased from 4°C to 0°C contraction occurs.
   D. A change of temperature of 15°C is equivalent to a change of temperature of 15K.

2. Why does running a jar under hot water make it easier to open? A. Because hot things are more malleable.
   B. Because the metal expands into the spaces between the glass threads.
   C. Because the gaps between the threads and the lid get larger as it expands.
   D. Because the gaps between the threads and the lid get smaller as it expands.

3. A material of length L_1 at temperature $\theta_1 K$ is subjected to a temperature rise of θK. The coefficient of linear expansion of the material αK^{-1}. What is the expansion of the material?
   A. $L_2(1 + \alpha\theta)$ B. $L_1\alpha(\theta - \theta_1)$ C. $L_1[1 + \alpha(\theta - \theta_1)]$ D. $L_1\alpha$

4. Which of the following is the best definition of thermal expansion? A. Molecules moving faster.
   B. An object never changing in size.
   C. An object in size due to increased temperature.
   D. An object remaining the same size no matter the temperature.

5. What is the symbol used for volumetric expansion?
   A. γ B. β C. L D. α

6. If you heat up an object that contains holes and crevices, what happens to those holes?
   A. They remain same size.
   B. They increase in size at the same rate as the object itself.
   C. They increase in size at a rate greater than the object itself.
   D. They decreased in size at a rate slower than the object itself.

7. Some iron has a coefficient of linear expansion of $12 \times 10^{-6} K^{-1}$. A 100mm length of iron piping is heated through 20K. How much the pipe extends?
   A. 0.24mm   B. 0.024mm   C. 2.4mm   D. 0.0024mm

8. If the coefficient of linear expansion is A, the coefficient of superficial expansion is B and the coefficient of cubic expansion is C, which of the following is false?
   A. $C = 3A$ B. $A = {}^{B}$ 23   C. $B \frac{3}{2} = C$ D. $A = {}^{C}$

9. What happen to the amplitude of vibration of the atoms or molecules on an object when cooling?
   A. Increases   B. Decrease   C. Remains same   D. Remains constant

10. In what condition does the molecules of a solid vibrate with larger amplitude?
   A. Zero temperature   C. Higher temperature
   B. Lower temperature   D. Pressure

11. The volume of a rectangular block of iron at a temperature t_1 is V_1. The temperature is raised to t_2 and the volume to V_2. If the coefficient of linear expansion of iron is α, the volume V_1 is given by:
   A. $V2[1 + \alpha(t2 - t1)]$ B. $1+3\alpha V(t22-t1)$ C. $3V2\alpha(t2 - t1)$ D. $1+\alpha(Vt22-t1)$

12. What is the cause in the increase in breadth, length, and thickness of a substance?
   A. Boiling   B. Fusion   C. Stress   D. Thermal expansion

13. In what season does the thermal expansion compensate for gaps that are left in railway?
   A. Rainy season   C. Hot season
   B. Winter   D. Wind

14. A composite rod made of copper ($1.8 \times 10^{-5} K^{-1}$) and steel $\alpha = 1.2 \times 10^{-5} K^{-1}$ is heated. What will happen to the composite rod made of copper and steel after heating?
   A. It shrinks.   C. It bends with steel on concave side.
   B. It does not expand.   D. It bends with copper on concave side

15. The length of a 100mm bar of metal increases by 0.3mm when subjected to a temperature rise of 100 K. What is the coefficient of linear expansion of linear expansion of the metal?
   A. $3 \times 10^{-3} K^{-1}$ B. $3 \times 10^{-4} K^{-1}$ C. $3 \times 10^{-5} K^{-1}$ D. $3 \times 10^{-6} K^{-1}$

Additional Activities

IN-THERMAL PROBLEM

Direction: Read and analyse the problem below and perform the given tasks. Observe the use of correct significant figures for your final answer.

1. A concrete sidewalk is constructed between two buildings on a day when the temperature is 25°C. The sidewalk consists of two slabs, each three meters in length of negligible thickness. As the temperature rises to 38°C, the slabs expands, but no space is provided for the thermal expansion. The building do not move, so the slab buckle upward. What is the change in length of each slab associated with the temperature change?

2. A 3cm silver metal cube whose initial temperature 20°C was heated at about 760°C. What will be its new volume if the coefficient of volume expansion β is equal to $57 \times 10^{-6} C°^{-1}$?

Answer Key

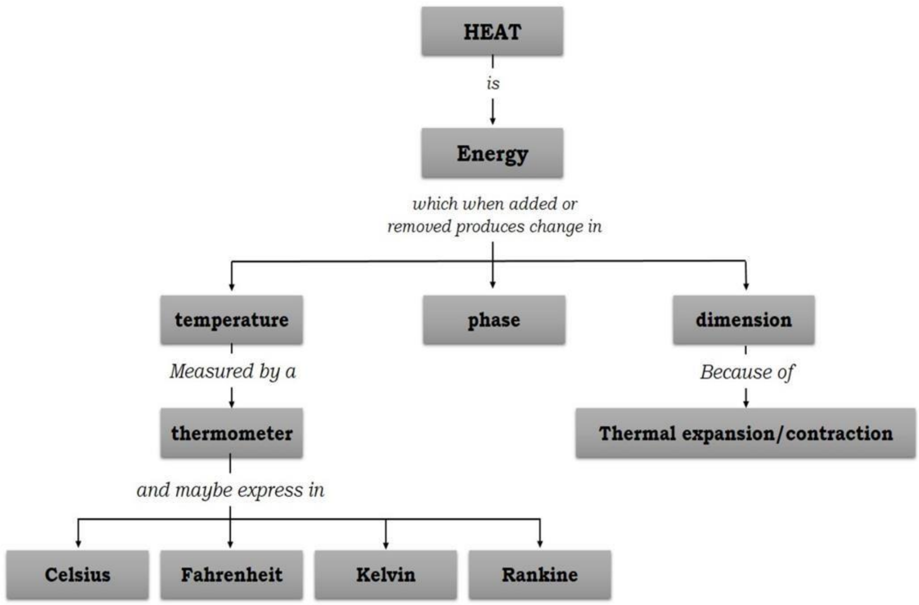
Pre-Assessment

1.C	11.D
2.B	12.C
3.B	13.C
4.B	14.C
5.C	15.C
6.B	
7.C	
8.A	
9.B	
10.C	

ACTIVITY 1: What's the Word....That's the Word

1.Expansion
2.Coefficient
3.Temperature
4.Length
5.Volume

ACTIVITY 2: Concept Box



ACTIVITY 3: Mix and Match

1. E-Temperature
2. D-Beta
3. A-Length
4. B-Alpha
5. C-Volume

ACTIVITY 4: Metalinearity

2 a. & 3, 1, 4
3 b ,2 , 1, 4

ACTIVITY 7: Thermal Filler

1. Thermal expansion
2. Temperature
3. Closely packed together
4. Contract
5. Coefficient of linear thermal expansion
6. Proportional
7. Linear Expansion
8. Volume Expansion
9. Length
10. Width

ACTIVITY 6: Bridge of Contract

SOLUTION:

STEP 1 Use the equation for the linear thermal expansion $\Delta L = \alpha L \Delta T$ to calculate the change in length, ΔL. Use the coefficient of linear expansion α, for steel and note that the change in temperature, ΔT, is 25°C

Given:

$\alpha = 12 \times 10^{-6} C^{\circ -1}$

$\Delta T = T_{final} - T_{initial} = 40°C - 15°C = \mathbf{25}C°$

$L = 0.09m$

STEP 2 Plug all of known values into the equation to solvefor ΔL.

$\Delta L = \alpha L \Delta T$

$\Delta L = \left(\frac{12 \times 10^{-6}}{\cancel{C°}}\right)(0.09m)(\mathbf{25}\cancel{°C})$

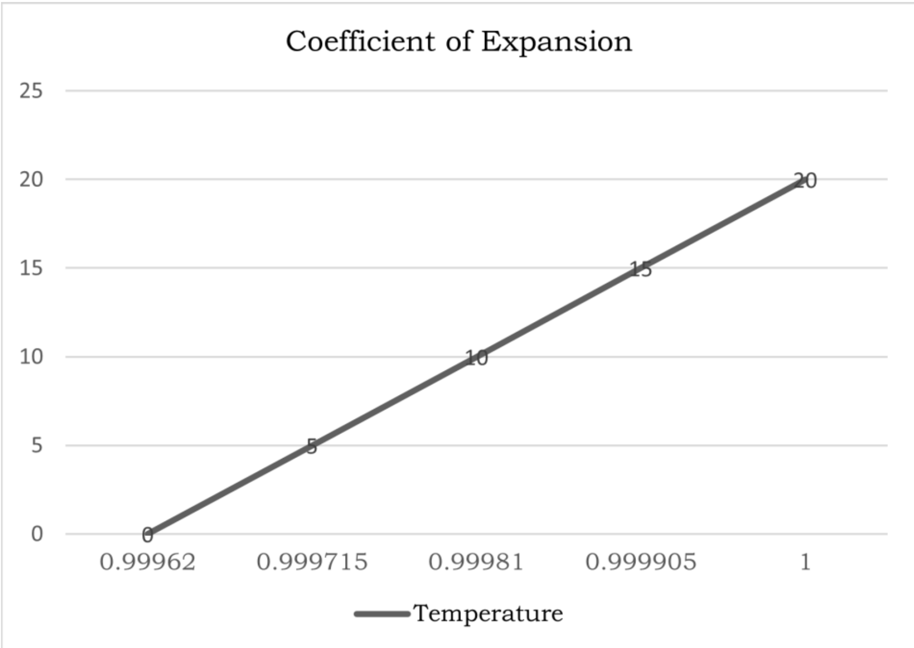
$\boldsymbol{\Delta L = 2.7 \times 10^{-5} m}$

Activity 8: Coefficient of Expansion

1. The measured length changes as the temperature changes. When the temperature fell below the initial measurement temperature of 20°C the material contracted. Above this temperature is expanded.

2. The amount of expansion and contraction for a given temperature change depends on the material used so, in general, these results would not be replicated if the experiment used a different material.

3. The metal will be cut to 1m at the temperature specified, in this case 20°C. As you see from the data, this measurement can be subjected to change due to temperature differences. Also, the length can only be cut as accurately as the cutting machine allows. In reality when producing of a number of lengths of a desired dimension a distribution of actual cut lengths will beproduced. For a good cutting machine the average should be very near the required length. The required length (at a stated temperature) is called the normal length and variations of this should be within specified tolerances.



4. The results show that this change in length is small compared with the initial length. This means that if you plot the data you have a very small scale on the y-axis and a requirement to keep a large number of decimal places, as shown in the graph

5. The gr adient of the graph gives the thermal expansion of coefficient of the material. This tells an engineer the change in length in meters that occurs per meter of material initially present per °C change in temperature.

   The gradient is given as

$$\alpha = \frac{L_{final} - L_{initial}}{T_{final} - T_{initial}} = \frac{\mathbf{1.000000 - 0.999620}}{\mathbf{20 - 0}} = \mathbf{1.9 \times 10^{-5}{}^{\circ}C^{-1}}$$

   This is the thermal expansion coefficient in units of $^{\circ}C^{-1}$

Post-Assessment

1. A	6. C	11. D
2. C	7. D	12. B
3. C	8. C	13. C
4. D	9. A	14. A
5. D	10. D	15. C

Additional Activity: In-Thermal Problem

1. **STEP 1**: Use the equation for the linear thermal expansion $\Delta L = \alpha L \Delta T$ to calculate the change in length, ΔL. Use the coefficient of linear expansion, α, for steel and note that the change in temperature, ΔT, is 13°C

   Given:
   $\alpha = 17 \times 10^{-6} C^{\circ -1}$
   $\Delta T = T_{final} - T_{initial} = 38°C - 25°C = \mathbf{13 C°}$
   $L = 3.0\, m$

   STEP 2: Plug all of known values into the equation to solve for ΔL.

   $$\Delta L = \alpha L \Delta T$$

   $$\Delta L = \left(\frac{17 \times 10^{-6}}{\cancel{C°}}\right)(3.0m)(\mathbf{13}\cancel{°C})$$

   $$\Delta L = \mathbf{0.00047m \approx 4.7 \times 10^{-4} m}$$

   The change in length of each slab associated with the temperature change is 0.00047 m. That is why the buckling of a sidewalk is one consequence of not providing sufficient room for expansion. As a result, engineers incorporate expansion joints or spaces along bridge and roads.

2. **STEP 1**: Use the equation for the volume thermal expansion $\Delta V = \beta V \Delta T$ to calculate the change in volume, ΔV. Use the coefficient of volume expansion, β, for silver and note that the change in temperature, ΔT, is 740°C

   Given:
   $\beta = 57 \times 10^{-6} C^{\circ -1}$
   $\Delta T = T_{final} - T_{initial} = 760°C - 20°C = \mathbf{740 C°}$
   $V = s^3 = (3cm)^3 = \mathbf{9cm^3}$

   STEP 2: Plug all of known values into the equation to solve for ΔV.

   $$\Delta V = \beta V \Delta T$$

   $$\Delta V = \left(\frac{57 \times 10^{-6}}{\cancel{C°}}\right)(\mathbf{3cm^3})(\mathbf{740}\cancel{C°})$$

   $$\Delta V = \mathbf{0.12654cm^3 \approx 0.13cm^3}$$

References

Cutnell Johnson, John D. & Kenneth W.,2007. *Physics 7th Edition.* Illonois: John Wiley & Sons, Inc (Asia),pp.352-359

Hugh D. Young & Roger A. Freedman. 2014. *Sears and Zemansky' University Physics with Modern Physics Technology Update 13th Edition.* England: Pearson Education.,pp340-345

Kirkpatrick, Larry D & Francis, Gregory E.. 2010. *Physics: A Conceptual World.* Vol. 7th Edition. Canada: Brooks/Cole Cengage Learning.,pp.275-277

Silverio, Angelina A., 2011. *Physics; Exploring Life Through Science Second Edition.* Quezon City: Phoenix Publishing House Inc.,pp.275-278

Silverio, Angelina A. 2017. *Exploring Life Through Science Series; General Physics.* Quezon City: Phoenix Publishing House Inc.,pp. 521-527

Walker, Jean. 2014. *Halliday and Resnick Fundamentals of Physics.* Vol. 10th Edition. USA: John Wiley and Sons.,pp.520-522

EDITOR'S NOTE

This Self-learning Module (SLM) was developed by DepEd SOCCSKSARGEN with the primary objective of preparing for and addressing the new normal. Contents of this module were based on DepEd's Most Essential Learning Competencies (MELC). This is a supplementary material to be used by all learners of SOCCSKSARGEN Region in all public schools beginning SY 2020-2021. The process of LR development was observed in the production of this module. This is version 1.0. We highly encourage feedback, comments, and recommendations

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