7
Chapter

Temperature and Its Measurement

We'll cover the following key points:

- Temperature
- Thermometer

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Learning Outcomes

By the end of this chapter, students will be able to:

- Understand the concept of temperature and its significance in daily life.
- Identify and explain the various types of thermometers and their specific uses.
- Learn how to measure temperature accurately using different types of thermometers.
- Analyze the impact of temperature variations on the environment and living organisms.

Guidelines for Teachers

The educator can introduce this topic by explaining what temperature is and its importance in our daily lives. Discuss how temperature is measured and the tools used, such as thermometers. To engage students, educators can conduct hands-on activities like measuring the temperature of different objects or environments. Encourage discussions on how temperature affects daily routines, weather, and ecosystems. The educator should create a collaborative environment that inspires curiosity and practical learning.

NCF Curricular Goals and Competencies

This chapter aligns with the following curricular goals and competencies:

CG-4 (C 4.1, 4.2, and 4.3) explores the concept of temperature, its measurement techniques, and its significance in understanding environmental and scientific phenomena.

Introduction:

Temperature measures the hotness or coldness of a substance, reflecting the average kinetic energy of its particles. Thermometers, based on thermal expansion or electrical resistance, are essential for weather forecasting, industry, and medicine.

In History...

Early temperature measurement began with Galileo's thermoscope in the 17th century. Fahrenheit introduced the mercury thermometer and Fahrenheit scale in 1714, followed by Celsius's widely used scale in 1742.

Temperature

Arjun and Priya are in the kitchen, observing a bowl of ice and a steaming kettle.

Temperature is a fundamental concept that refers to the measure of how hot or cold a body is. It provides a quantitative way to express the degree of heat within a substance or object. A hotter body has a higher temperature compared to a colder one, signifying that it contains more thermal energy. This difference in thermal energy allows us to compare and determine the relative heat levels between two bodies. By measuring the temperature difference, we can analyze the heat transfer process, as heat naturally flows from a body with a higher temperature to one with a lower temperature. This concept is crucial in understanding various natural phenomena, from weather patterns to the behavior of substances as they undergo changes in state, such as melting, boiling, or freezing. Temperature also plays a vital role in daily life, influencing everything from our choice of clothing to the functioning of devices and machinery.

Temprature Scale

Temperature is measured using different scales, each designed for specific purposes. The three primary scales are Celsius, Fahrenheit, and Kelvin:

- **Celsius (°C):** This scale is widely used in scientific and everyday contexts. It defines the **freezing point** of water as 0°C and the **boiling point** as 100°C under standard atmospheric pressure.
- **Fahrenheit (°F):** Predominantly used in the United States, the Fahrenheit scale sets the freezing point of water at 32°F and the boiling point at 212°F.
- **Kelvin (K):** The Kelvin scale is the SI unit of temperature used in scientific research. It starts at absolute zero (0 K), the theoretical point where particle motion ceases. The freezing and boiling points of water are 273.15 K and 373.15 K, respectively.

These scales are interrelated through specific conversion formulas, allowing easy conversion between them.

Temperature Scale Table

Scale	Freezing Point of Water	Boiling Point of Water	Absolute Zero
Celsius (°C)	0°C	100°C	-273.15°C
Fahrenheit (°F)	32°F	212°F	-459.67°F
Kelvin (K)	273.15 K	373.15 K	0 K

Relationship Between Scales

Celsius to Fahrenheit: $F = \frac{9}{5}C + 32$

Fahrenheit to Celsius: $F = \frac{5}{9}(F - 32)$

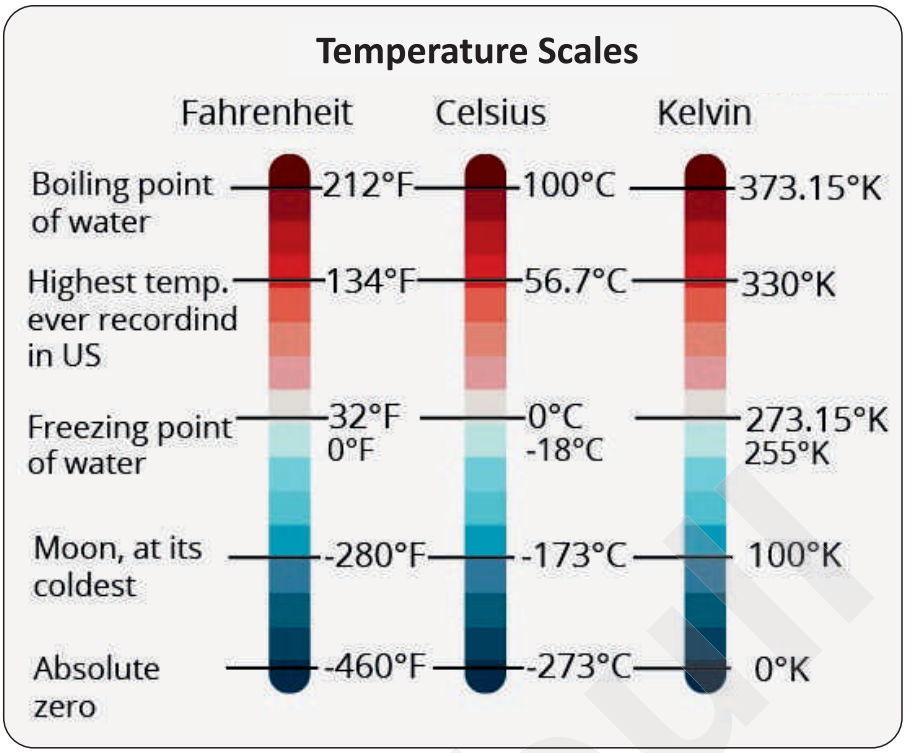
Celsius to Kelvin: $K = C + 273.15$

Kelvin to Celsius: $C = K - 273.15$

KEYWORDS

Freezing Point: The freezing point is the temperature at which a liquid turns into a solid. For water, this happens at 0°C.

Boiling Point: The boiling point is the temperature at which a liquid turns into a gas. For water, this happens at 100°C.



Practice Problems on Temperature Conversion

Celsius to Fahrenheit (°C to °F):

- Convert 25°C to Fahrenheit.
- The temperature of a room is 0°C. What is it in Fahrenheit?
- A scientist measures the temperature of a chemical reaction as 100°C. Find its equivalent in Fahrenheit.

Fahrenheit to Celsius (°F to °C):

- Convert 68°F to Celsius.
- The temperature outside is recorded as 50°F. What is it in Celsius?
- A freezer maintains a temperature of 10°F. Calculate its equivalent in Celsius.

Celsius to Kelvin (°C to K):

- Convert 37°C (normal human body temperature) to Kelvin.
- If the temperature of a liquid is -20°C, what is its value in Kelvin?
- The freezing point of water is 0°C. Express this temperature in Kelvin.

Kelvin to Celsius (K to °C):

- Convert 300 K to Celsius.
- A scientist cools a gas to 77 K. What is this temperature in Celsius?
- The boiling point of water is 373.15 K. Express it in Celsius.

Let's recall what we know

Apply Concept in Context

Apply

- What are the freezing and boiling points of water in the Celsius scale?
- Why does temperature affect the rate of chemical reactions? Explain.
- How does the temperature of water change when heated on a stove?

Skills Covered: Brainstorming, Research, Critical and logical thinking, Applicative thinking

Examine Further

Analyse

- What is the purpose of using different temperature scales in scientific experiments?
- Why do you feel more comfortable in the spring compared to the extreme heat of summer?

Skills Covered: Critical and logical thinking, Applicative thinking. Brainstorming

Self-Assessment Questions

Evaluate

- Define heat and how it differs from temperature.
- Explain why the Kelvin scale is used in scientific studies.
- If the temperature of a place is 30°C, what would it be in Fahrenheit?

Skills Covered: Brainstorming, Critical thinking, Research, Critical and logical thinking

Creative Insight

Create

Create a chart comparing the Celsius, Fahrenheit, and Kelvin scales, including the specific temperatures at which water freezes and boils in each scale.

Skills Covered: Creativity, Critical and logical thinking, Brainstorming

Bloom's Taxonomy

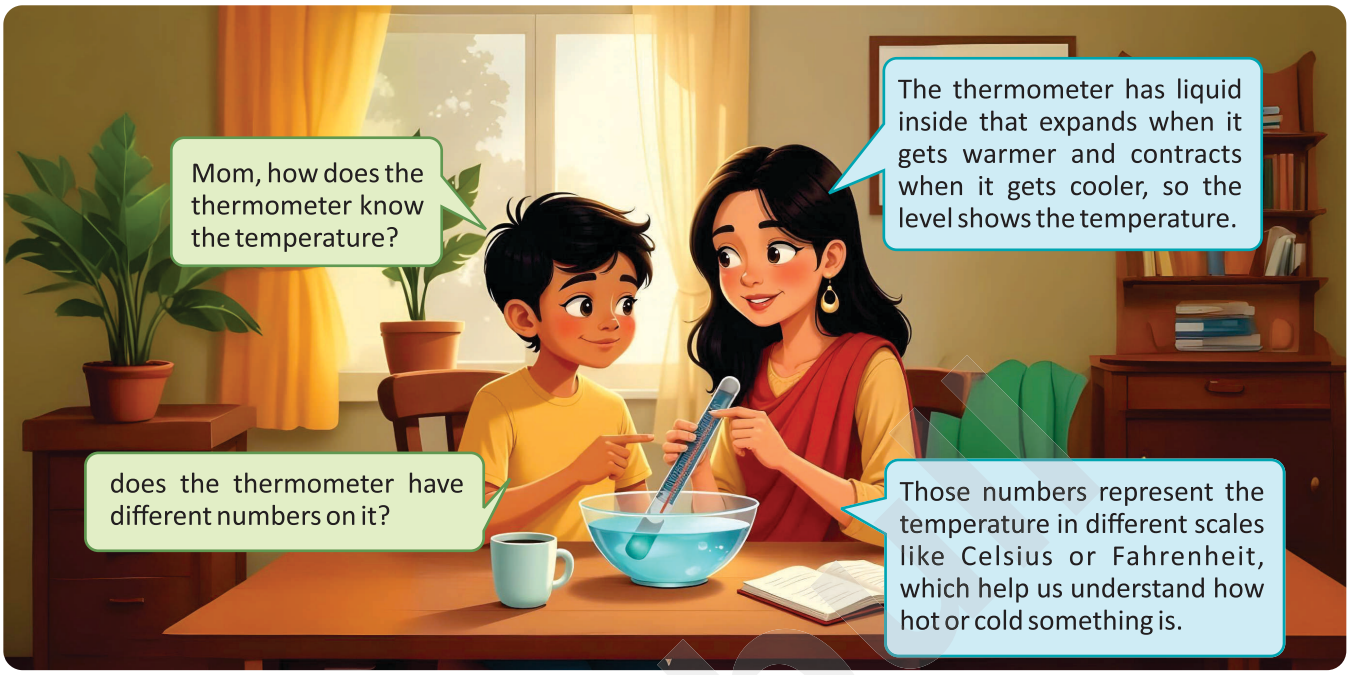
SCAN TO ACCESS

Take a Task

Watch Remedial

Thermometer

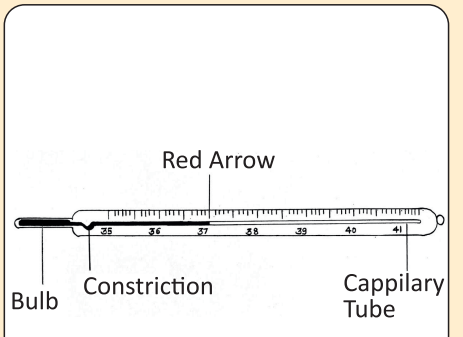
Arjun and Priya are in the kitchen, observing a bowl of ice and a steaming kettle.



A thermometer is a device used to measure temperature. The word "thermometer" is derived from two Latin words: "thermo," meaning heat, and "meter," meaning a measuring device. Thermometers are essential tools in various fields, as they measure temperature in units such as degrees Celsius, Fahrenheit, or Kelvin. There are two main types of thermometers commonly used: clinical thermometers and laboratory thermometers. Clinical thermometers are designed for measuring human body temperature, often used in medical settings, while laboratory thermometers are used for precise temperature measurements in scientific experiments and processes. Each type is calibrated to provide accurate readings within its intended range of use.

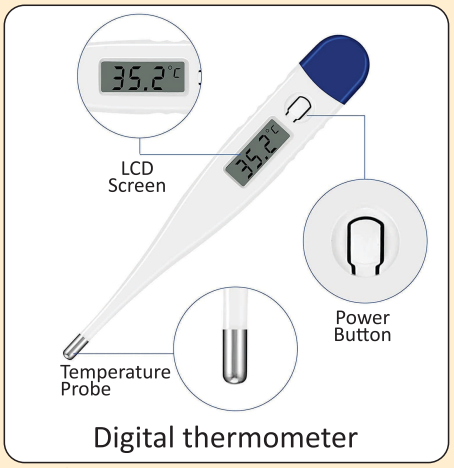
Clinical thermometer

A clinical thermometer is a device specifically designed to measure body temperature. It is commonly referred to as a "doctor's thermometer" due to its widespread use in medical settings. Clinical thermometers have evolved over time, with earlier models utilizing mercury as the thermometric liquid, while modern versions often use digital technology.



Mercury thermometer

Traditionally, a clinical thermometer consists of a glass tube containing a thin, long capillary tube. The tube houses a bulb at one end, which holds a thermometric liquid—typically either mercury or alcohol. In the case of mercury thermometers, the glass tube has a small kink just above the bulb, which prevents the mercury from flowing back into the bulb when the thermometer is removed from the body. This feature ensures that the mercury remains at the highest level reached during the measurement.



Digital thermometer

The normal body temperature of a healthy individual is typically 37°C, with a typical range between 35°C to 42°C. However, this value can vary slightly depending on factors such as age, time of day, and activity level. For instance, a perfectly healthy individual might have a body temperature slightly above or below 37°C. For many years, the 37°C mark has been considered the standard, and it is also equivalent to 98.6°F on the Fahrenheit scale.

With the advancement of technology, digital thermometers have largely replaced mercury thermometers in many households and medical practices. Digital thermometers are powered by batteries and provide more convenient, quick, and safe temperature readings. These thermometers work by displaying the temperature on a digital screen, eliminating the need for interpreting mercury levels. In addition, digital thermometers are often designed for use under the tongue, in the armpit, or rectally. When used under the armpit, the temperature reading may be approximately 0.5°C to 1°C lower than the actual body temperature.

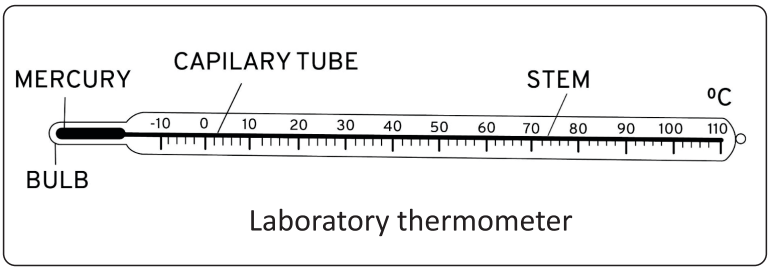
Laboratory Thermometer

A **laboratory thermometer** is a specialized device used to measure the temperature of solutions and substances in scientific experiments. Unlike clinical thermometers, which are designed for body temperature measurement, laboratory thermometers are built for a broader range of temperatures typically encountered in a lab setting. They are commonly used to monitor the temperature of liquids and chemical reactions in controlled environments. These thermometers typically have a range from **-10°C to 110°C**, allowing them to measure temperatures in both cold and moderately hot conditions.

The laboratory thermometer consists of a **long, narrow, uniform glass tube** with a sealed end containing a bulb filled with a thermometric liquid—usually mercury or alcohol. The tube is marked with a **Celsius scale**, and a **narrow column of liquid** is visible within the tube, which moves in response to temperature changes. As the temperature of the solution being measured increases, the liquid in the thermometer expands, causing the level of the liquid column to rise. Conversely, as the temperature decreases, the liquid contracts, causing the column to fall.

The temperature reading is determined by observing the mark on the Celsius scale that aligns with

the top of the liquid column. The scale is typically divided into increments, and the size of each division indicates the degree of temperature change. For instance, on many laboratory thermometers, the temperature difference between **0°C and 10°C** or between **10°C and 20°C is 10°C**, and there are **10 divisions** between these two marks. Therefore, each small division represents a **1°C** change. This means that the **smallest temperature increment measurable by the thermometer is 1°C,** although thermometers with finer divisions (such as 0.1°C) are also available in certain laboratory setups.



Laboratory thermometer

Laboratory thermometers are available with different temperature ranges and divisions based on their intended use. It is crucial to examine the specific thermometer being used to understand its range and precision. For example, some thermometers may have a finer scale with smaller divisions to measure temperature more accurately, especially for sensitive experiments requiring precise temperature control.

Note: Laboratory thermometers are typically made of glass, so they can be fragile. It is important to handle the thermometer with care. If the thermometer is dropped or hits a hard surface, it can break, potentially spilling hazardous **mercury** or chemicals. Never hold the thermometer by the bulb, as this increases the risk of damage. Additionally, do not allow the bulb to touch any surface or objects other than the solution being measured, as this can interfere with the accuracy of the reading.

Precautions and Handling Tips for Thermometer

Avoid Shaking the Thermometer Too Much: Shaking the thermometer can cause the mercury to move erratically, making it difficult to read. Always handle the thermometer gently.

Use the Right Thermometer: Make sure to use a laboratory thermometer that is designed for the temperature range you need. For example, if you need to measure very high or low temperatures, ensure the thermometer is calibrated to handle those extremes.

Keep It Clean: After using the thermometer, clean it with an appropriate disinfectant or solvent to remove any residues. This is particularly important in a laboratory setting where contamination can affect the results of future experiments.

Proper Storage: Store laboratory thermometers in a safe place where they won't be exposed to extreme conditions that could damage them. Use protective cases or holders to prevent breakage.

KEYWORDS

Mercury: It is a shiny, liquid metal used in thermometers because it expands and contracts uniformly with temperature changes. This makes it easy to measure temperature accurately.

Air Temperature

Air temperature, also known as atmospheric temperature, is a measure of how hot or cold the air is at a given location and time. It is one of the most fundamental measurements in meteorology, used to assess weather conditions and understand the local climate. You may have observed thermometers hung on the walls in various settings, such as your school laboratory, doctor's office, or hospitals. These thermometers are typically used to measure the **ambient temperature** of the room, providing an approximate reading of how warm or cool the environment is.

Air temperature plays a crucial role in determining the weather patterns we experience on a daily basis. It is influenced by a variety of factors, including the season, **time of day, geographical location**, and **weather systems**. For example, the **sun's heat** causes air temperatures to rise during the day, while **cooler night air** results in lower temperatures after sunset.

The measurement of air temperature is vital for **weather forecasting, agriculture, building construction**, and even **healthcare**. In meteorology, accurate temperature readings help predict weather conditions, such as whether it will be hot, cold, or moderate, and how these conditions will evolve throughout the day or week. In the context of agriculture, knowing the air temperature helps determine the right time for planting crops and assessing the risk of frost.

As the seasons change, the air temperature undergoes natural fluctuations. During the **summer months**, temperatures generally increase due to the Earth's tilt and the longer duration of daylight. In contrast, **winter months** bring colder temperatures as the sun's rays are less direct and daylight hours are shorter. In many regions, these seasonal variations lead to the cyclical patterns of hot and cold air that characterize different times of the year.

Air temperature also affects other **environmental factors** such as **humidity, precipitation**, and **wind speed**. For instance, high temperatures often coincide with increased evaporation, leading to higher humidity levels in the air. Similarly, temperature differences between regions can drive **wind patterns** and influence the occurrence of storms.

Importance of Air Temperature

Understanding air temperature is essential for a variety of reasons. For instance:

- **Weather Forecasting:** Air temperature data is one of the most important variables used in weather forecasting. It helps meteorologists predict weather conditions like heatwaves, cold fronts, and storms.
- **Agriculture and Farming:** Farmers rely on accurate air temperature measurements to determine the best planting and harvesting times for crops. Extremely low temperatures can cause damage to plants, while excessively high temperatures can lead to droughts or heat stress in crops.

- **Public Health:** Air temperature influences public health in various ways. For example, extremely high temperatures can lead to heatstroke and dehydration, while extremely low temperatures can cause **hypothermia** and frostbite. Knowing the temperature helps people take appropriate precautions to protect their health.
- **Energy Use:** The air temperature also affects how much energy is needed to heat or cool a building. In areas with harsh winters or hot summers, accurate temperature measurements are crucial for managing energy consumption and maintaining comfortable living conditions.

Seasonal Variations in Air Temperature

- As the seasons change, so does the air temperature. During the **summer months**, when the Earth's axis tilts toward the sun, we experience longer days and shorter nights, leading to higher temperatures. These warmer conditions are typically associated with **higher humidity, more precipitation**, and an increase in **thunderstorms.**
- In contrast, during the **winter months**, the Earth's axis tilts away from the sun, causing shorter days, longer nights, and lower temperatures. The cooler temperatures during winter often lead to reduced humidity levels, drier air, and in many places, **snowfall or frost**.

Did you know

Anna Mani (1918-2001), often referred to as the **Weather Woman of India**, was a pioneering Indian scientist who made significant contributions to meteorology and renewable energy. Throughout her career, she invented and developed various weather measurement instruments, which greatly reduced India's reliance on foreign sources for such tools. Her work played a crucial role in strengthening India's meteorological capabilities.

In addition to her work in weather instrumentation, Anna Mani was also ahead of her time in exploring renewable energy. She conducted extensive research on the potential of **wind and solar energy** in India, contributing to the country's growing role as a leader in **renewable energy.** Her efforts laid the groundwork for India's future developments in sustainable energy solutions, helping pave the way for the nation's progress in addressing climate change and energy needs. Anna Mani's legacy continues to inspire future generations in both meteorology and environmental science.

KEYWORDS

Hypothermia: It is a condition that happens when your body loses heat faster than it can produce, causing your body temperature to drop dangerously low.

Let's recall what we know

SCAN TO ACCESS

Take a Task

Watch Remedial

Bloom's Taxonomy

Apply Concept in Context

Apply

- Measure the temperature of different objects (such as water, metal, and wood) using a laboratory thermometer. Record the temperatures at various times of the day and summarize your observations in a table.
- How might external factors (such as humidity or altitude) affect the accuracy of a thermometer's reading?

Skills Covered: , Critical and logical thinking, Brainstorming, Organization, Analytical thinking, Communicative skills

Examine Further

Analyse

- Why do you think laboratory thermometers are preferred over clinical thermometers in scientific experiments?
- How does the material of the liquid used in a thermometer (e.g., mercury vs. alcohol) affect its performance?
- Can temperature be measured without contact with an object? If so, how?

Skills Covered: Critical and logical thinking, Problem-solving, Brainstorming, Research, Analytical thinking

Self-Assessment Questions

Evaluate

- Define temperature and explain how it can be measured using different types of thermometers.
- What are the factors that could lead to inaccurate readings on a digital thermometer?
- Discuss how temperature influences various physical and chemical properties of materials.

Skills Covered: Knowledge recall, Critical thinking, Problem-solving, Research, Analytical skills

Creative Insight

Create

Make a video demonstration explaining how to use a laboratory thermometer in different scenarios, highlighting the differences between types of thermometers and their applications.

Skills Covered: Creativity, Digital-age literacy, Critical thinking, Communication, Problem-solving

SUMMARY

Temperature

Temperature measures how hot or cold an object or environment is. It influences heat flow, states of matter, and energy transfer, reflecting the average kinetic energy of particles. Common units include Celsius (°C), Fahrenheit (°F), and Kelvin (K).

- **Definition:** Measures the average kinetic energy of particles.
- **Significance:** Affects heat flow, matter states, and energy transfer.
- **Units:** Commonly measured in °C, °F, and K.

Temperature Scales

Celsius, Fahrenheit, and Kelvin scales measure and compare temperatures using different reference points and units.

Thermometers

Thermometers are instruments used to measure temperature. They function by detecting the changes in physical properties, such as the expansion of liquids or gases, as temperature changes. Thermometers are commonly classified based on their application and the type of measurement they provide.

Clinical Thermometer

A clinical thermometer is designed specifically to measure body temperature. It is used in medical settings and at home to check the health status of individuals. Traditionally, these thermometers used mercury, but digital versions have largely replaced mercury thermometers due to safety concerns.

- **Structure:** It consists of a long, narrow glass tube with a bulb at one end. The bulb contains a liquid (usually mercury or alcohol) that expands with an increase in temperature.
- **Range:** It typically measures temperatures from 35°C to 42°C (95°F to 107.6°F), the normal range for human body temperature.
- **Usage:** The thermometer is placed under the tongue, in the armpit, or rectally to obtain an accurate body temperature reading.
- **Safety Tip:** Clinical thermometers must be handled carefully, as mercury thermometers can break and release toxic mercury.

Laboratory Thermometer

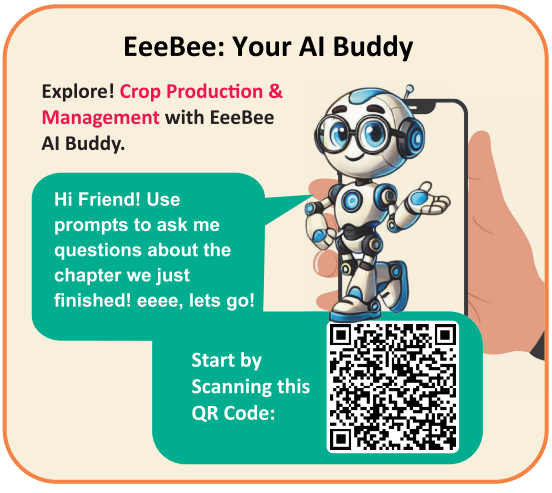
A laboratory thermometer is used for measuring the temperature of liquids or substances in scientific experiments. Unlike clinical thermometers, these are designed to handle higher or lower temperature ranges and are more precise.

- Measures temperatures in scientific experiments with a range of -10°C to 110°C.
- Contains mercury or alcohol in a wider tube with a precise scale.
- Used by placing it in a substance to read the liquid column's height.

Air Temperature

Air temperature measures the temperature of the surrounding atmosphere. It is an essential parameter in weather forecasting and environmental studies, as it determines the local climate and affects numerous aspects of daily life, such as energy usage, agriculture, and health.

- Indicates the surrounding atmosphere's temperature, essential for weather and climate studies.
- Measured using outdoor thermometers in shaded areas to avoid sunlight interference.
- Influenced by seasons, time of day, and location, with tools like digital or alcohol thermometers.



EXERCISE

That turn curiosity into confidence—let's begin!

Gap Analyzer™
Take a Test

A. Choose the correct answer.

1. What is the SI unit of temperature?
   (a) Celsius ☐ (b) Fahrenheit ☐
   (c) Kelvin ☐ (d) Joule ☐
2. Which thermometer is used to measure the temperature of the human body?
   (a) Laboratory thermometer ☐ (b) Digital thermometer ☐
   (c) Infrared thermometer ☐ (d) Clinical thermometer ☐
3. What happens to the mercury level in a thermometer when the temperature increases?
   (a) It falls ☐ (b) It rises ☐
   (c) It remains the same ☐ (d) It disappears ☐
4. Which of the following is a normal body temperature in Celsius?
   (a) 25°C ☐ (b) 37°C ☐
   (c) 50°C ☐ (d) 100°C ☐
5. What is the freezing point of water on the Fahrenheit scale?
   (a) 0°F ☐ (b) 32°F ☐
   (c) 100°F ☐ (d) 212°F ☐

B. Fill in the blanks.

1. The normal human body temperature is ____ degrees Celsius.
2. A thermometer uses ____ to measure temperature changes.
3. The ____ thermometer can measure both hot and cold temperatures accurately.
4. The boiling point of water is ____ degrees Celsius.
5. Temperature is a measure of the ____ energy of particles in a substance.

C. Write True or False.

1. Mercury is commonly used in traditional thermometers because it expands uniformly with temperature. _____
2. The Celsius and Kelvin scales are the same, except for the starting point. _____
3. A clinical thermometer can measure very high temperatures. _____
4. Body temperature is always measured in Kelvin. _____
5. Air temperature in extreme cold cannot be measured as thermometers freeze. _____

D. Define the following terms.

1. Temperature
2. Thermometer
3. Boiling Point
4. Freezing Point
5. Clinical Thermometer

E. Match the columns.

Column A	Column B
1. Clinical thermometer	(a) 100°C
2. Mercury	(b) Uniform expansion with heat
3. Laboratory thermometer	(c) Measures water boiling temperature
4. Kelvin scale	(d) Starts at absolute zero
5. Boiling point of water	(e) Used for body temperature

F. Give reasons for the following statements.

1. Mercury is preferred in thermometers for measuring temperature.
2. A clinical thermometer cannot be used to measure boiling water.
3. Air temperature in cold regions can be challenging to measure due to extreme conditions.
4. The Kelvin scale is used in scientific measurements.
5. Temperature affects the state of matter.

G. Answer in brief.

1. What is the difference between the Celsius and Fahrenheit scales?
2. Why are laboratory thermometers unsuitable for measuring body temperature?
3. How does a clinical thermometer work?
4. Explain why mercury is a good choice for use in thermometers.
5. What precautions should be taken while using a thermometer?

H. Answer in detail.

1. Explain the importance of measuring temperature accurately in daily life.
2. Compare and contrast the Celsius, Fahrenheit, and Kelvin scales.
3. Describe the construction and working of a clinical thermometer.
4. How does a laboratory thermometer differ from a clinical thermometer?
5. Discuss the role of thermometers in scientific and medical applications.

NEP Corner

Know about NEP 2020

Your Marks Won't Define You!

With the new focus on holistic progress cards, your personality, creativity, and extracurricular talents will shine.

Skill-based Activity

Curious Minds at Work

STEM

Observe and measure the temperature of a glass of water before and after adding ice. Write a question about how heat transfer affects the temperature. Using the scientific method, describe the steps to answer your question.

Skills Developed: Critical and logical thinking, Brainstorming, Analytical thinking, Problem-solving, Observation, Decision-making skills

Designing with Precision

Art

Draw and label the different parts of a clinical thermometer. Write a short description explaining how it works. Present your work to the class.

Skills Covered: Creativity, Critical and logical thinking, Applicative thinking

Comparing Thermometers

Group Activity

In groups, collect and study different types of thermometers (digital, clinical, and laboratory). Create a chart comparing their uses, advantages, and limitations. Present the chart in class.

Skills Developed: Teamwork, Critical thinking, Brainstorming, Communication, Applicative thinking

Technology in Focus

Case to Investigate

Research the role of air temperature in weather forecasting and climate studies. Write a short report explaining how air temperature is measured, its significance in meteorology, and its impact on daily weather patterns and seasonal changes.

Skills Developed: Research, Critical and logical thinking, Applicative thinking

Science Meets Sustainability

Aligning with SDGs

Research how innovations in temperature measurement technology help reduce energy consumption in industries. Highlight key examples and explain how this aligns with sustainable development goals.

Aligned with: SDG 12 – Responsible Consumption and Production

Skills Covered: Research, Problem-solving, Brainstorming, Ethical decision-making

Mapping Temperature Zones

Integrated Learning

Use the Internet to create a map of the world showing regions based on average temperatures (hot, temperate, cold). Explain how the climate influences the lifestyle of people in these zones.

Integrated Learning: Geography

Skills Covered: Analytical thinking, Critical thinking, Applicative thinking