Chapter 7

Temperature and its Measurement

> “Wrong measurements are worse than no measurements at all.”
>
> — Anna Mani

0677CH07



Lambok and his elder sister Phiban live in Shillong. One day they came home from school. Their parents were away at work and Lambok complained that he was feeling feverish. Phiban touched his forehead and felt that he might be having a fever. To confirm this, she took out the thermometer kept in the almirah. She washed its tip with soap and water, and measured Lambok's temperature. To her relief, she found that his temperature was normal. She washed the thermometer tip again, dried it and put it back. She then asked Lambok to change his school uniform, eat his lunch, and rest for some time.

Can it always be correctly judged, that a person has fever, only by touching the person? ?

7.1 Hot or Cold?

We know from experience that some bodies are hotter than others. For example, during summers, the tap water may be hotter than the cold water from a *matka* (earthen pot) or a

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refrigerator. We can realise this by merely touching the two samples of water. But can we always rely upon our sense of touch? Let us find out.

Activity 7.1: Let us investigate

- Take three large containers and label them A, B and C, as shown in Fig. 7.1.
- Pour warm water in container A, tap water in B and ice-cold water in C.
- We will conduct this activity in two parts — prediction and observation.
- Firstly, **predict** what will you feel if you
  - dip your right hand in A and left hand in C and keep them there for 1–2 minutes.
  - take out your hands from containers A and C, and place both hands simultaneously in B.

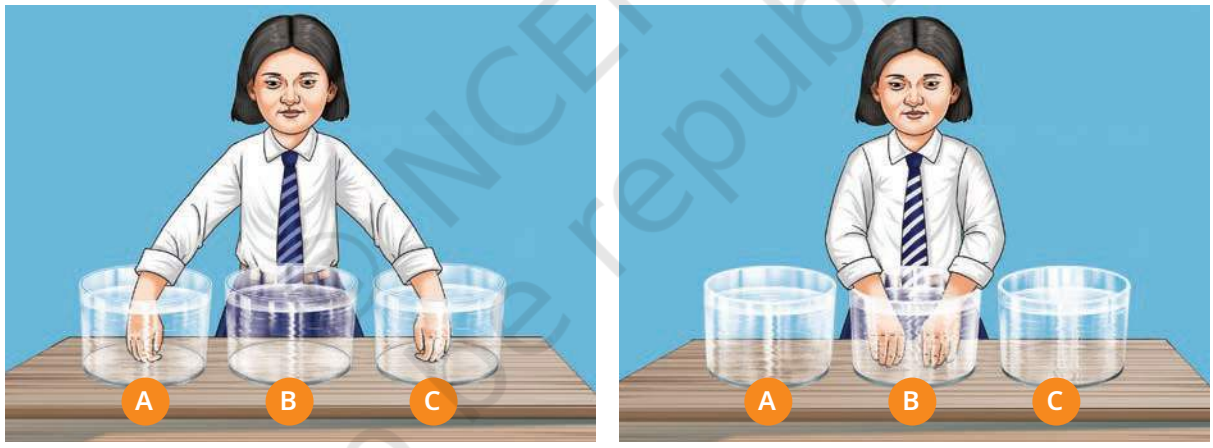


Fig. 7.1: Feeling hotness or coldness of water by dipping hands

- Write down your predictions.
  - What will my right hand feel on dipping it in B?

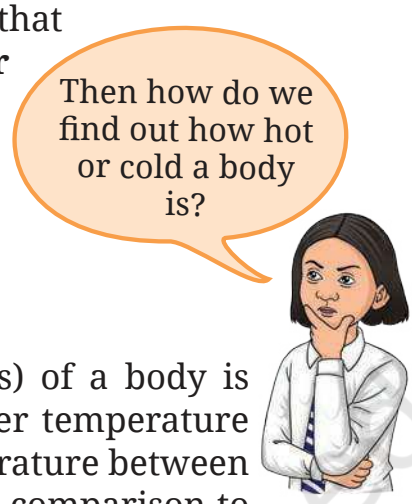
  - What will my left hand feel on dipping it in B?

- Now, conduct the activity and write your observations.

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Compare whether your observations match with your predictions. Did your right hand feel that the water in container B is cool, while your left hand felt that the same water is warm? What do you **infer** from these observations?

We cannot always rely upon our sense of touch to decide correctly whether a body is hot or cold.



7.2 Temperature

A reliable measure of hotness (or coldness) of a body is its **temperature**. A hotter body has a higher temperature than a colder body. The difference in temperature between the two bodies tells us how hot a body is in comparison to another body. A device that measures temperature is called a **thermometer**.

There are two kinds of thermometers that you are likely to come across—clinical thermometers and laboratory thermometers. Clinical thermometers are used to measure human body temperatures whereas laboratory thermometers are used for many other purposes. Let us now learn more about thermometers and how to use them to measure temperature.

7.3 Measuring Temperature

7.3.1 Clinical thermometer

You might be familiar with a thermometer, like that shown in Fig. 7.2, which is used for measuring our body temperature. It is called a clinical thermometer. Such thermometers show temperatures digitally. These are also known as digital clinical thermometers and run on batteries. These measure



Fig.7.2: A digital clinical thermometer

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temperature when the thermometer is placed in contact with a person's body.

For measuring temperature, the clinical thermometers generally use a scale called the **Celsius scale**. On this scale, the unit of temperature is **degree Celsius** and is denoted by °C.

Earlier, mercury thermometers were used for measuring the body temperature. But mercury is an extremely toxic substance and is difficult to dispose of if the thermometer breaks accidently.



Digital thermometers pose no such risk and also the numbers in its display are easier to read. Therefore, mercury thermometers are being replaced by digital thermometers. Temperature in a digital thermometer is determined with the help of heat sensors.

Do you know?

During the COVID-19 pandemic, some special thermometers were used, which could measure the temperature of a person from a distance. What were those?



They are non-contact thermometers, also called infrared thermometers. Such thermometers can measure temperature without touching a person's body and thus reduce the risk of spreading disease.



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Activity 7.2: Let us measure

Let us now use a digital clinical thermometer to measure body temperature. You may measure your own temperature as well as the temperature of some of your friends. Talk to your friends to find out who would be willing to get their body temperatures measured by you.

- Wash your hands and the tip of the digital thermometer with soap and water.
- Reset the thermometer by pressing the reset button.
- Place the thermometer under the tongue and close your mouth.
- Wait till the thermometer makes a beeping sound or flashes a light.
- Take it out from the mouth and read the temperature on the digital display.
- **Record** the temperature in Table 7.1.
- Clean the tip of the thermometer with soap and water, and dry it.
- Repeat the above steps for measuring the temperatures of your friends.

Precautions
to be taken while using a digital clinical thermometer

- To be used after reading the instruction manual of the thermometer.
- Tip of the thermometer to be washed with soap and water before and after use.
- While washing, care to be taken to keep the digital portion such as the display out of water.
- Do not hold the thermometer by the tip.

Table 7.1: Body temperatures of 10 persons

S. no.	Name	Temperature (°C)
1.		
.		
.		
.		
.		
10.		

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The normal temperature of a healthy human body is taken to be 37.0 °C. But in this activity, did you find that the normal temperature of every person was 37.0 °C? Or did you find the temperature slightly higher or lower for some people?

Do small children generally have slightly higher body temperatures as compared to adults? ?

Do old people, even when healthy, generally have lower body temperatures than young adults? ?

The temperature of every person may not be 37.0 °C. What we call normal temperature is the average body temperature of a large number of healthy people. A perfectly healthy person may, therefore, have a normal temperature slightly different from 37.0 °C. The body temperature is influenced by several factors, such as age, time of the day and activity level.

You may try measuring your own temperature at different times of the day and on different days. Record the thermometer readings in your notebook. After a month, analyse your temperature record and see if there are any variations. If yes, try to think what might be the reasons for that.

The temperature of human beings does not normally go below 35 °C or above 42 °C.

For measuring the body temperature of small children or old people, the digital thermometer can also be placed in the armpit. The temperature measured this way is about 0.5 °C to 1 °C lower than the actual body temperature.

There is another scale of temperature known as **Fahrenheit scale**. On this scale, the unit of temperature is **degree Fahrenheit** and is denoted by °F. A temperature measured as 37.0 °C on Celsius scale is equivalent to 98.6 °F on Fahrenheit scale. The Fahrenheit scale is not used in most scientific studies anymore. In scientific work, there is another scale of temperature known as **Kelvin scale**. On this scale, the unit for temperature is **kelvin** and is denoted by **K**. The **SI unit of temperature** is kelvin.

I have seen a friend of mine using a digital thermometer that reads temperature on a different scale. It shows the normal temperature of a healthy human body as 98.6 °F. What is the reason for this difference?



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All three temperature scales, Celsius, Fahrenheit and Kelvin are named in honour of the scientists who developed these scales.

We can easily convert the temperature from Celsius scale to Kelvin scale by using:

Temperature in Kelvin scale = Temperature in Celsius scale + 273.15

More to know!

The names of temperature scales—Celsius scale, Fahrenheit scale and Kelvin scale—start with a capital letter. For the units for temperature, degree Celsius and degree Fahrenheit, the word degree starts with a lower-case letter while Celsius and Fahrenheit start with a capital letter. The unit kelvin starts with a lower-case letter. The symbols of all units (°C, °F, K) are capital letters. Note that degree sign (°) is not written with K. A full stop is not written after the symbol, except at the end of a sentence. While writing the temperature, a space is left between the number and the unit. For temperatures more than one degree, use the plural of 'degree', that is, 'degrees', while writing the full form of the unit.

Can a clinical thermometer be used for measuring the temperature of boiling water? Or for measuring the temperature of ice?

No, the temperatures of boiling water and ice are outside the range of a clinical thermometer.

Do you know?

How was fever detected before thermometers were developed? Fever affects the pulse rate of a person. This was known even in olden days in India. However, apart from fever, some other situations also affect the pulse rate. Hence, pulse rate alone is not a reliable indicator of fever.



How can we measure temperatures beyond the range of a clinical thermometer?

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Fig.7.3(a): A laboratory thermometer

7.3.2 Laboratory thermometer

There are many types of laboratory thermometers but the one that might be available in your school laboratory may look like the one shown in Fig. 7.3a. It consists of a long, narrow, uniform glass tube which is sealed. At one end of the tube is a bulb which contains a liquid. Outside the bulb, in the tube, a narrow column of liquid can be seen. There is a Celsius scale marked along the tube. The liquid column rises or falls with change in temperature. The mark of the Celsius scale with which the top level of the liquid column coincides is the temperature reading.

Do you know?

The liquid used in the laboratory thermometer is generally alcohol (coloured red to make it easily seen) or mercury.

Activity 7.3: Let us observe

Let us try to find the temperature range of a given laboratory thermometer.

- Take a laboratory thermometer and observe it carefully.
- Note down the following:
  - What is the lowest temperature it can measure?

  - What is the highest temperature it can measure?

  - So, the range of this thermometer is ----------

Precautions
to be taken while using a laboratory thermometer

- Handle with care. If it hits against some hard object, it can break.
- Do not hold it by the bulb.

Now look at the thermometer shown in Fig. 7.3a carefully. Can you tell its range? Its range is from –10 °C to 110 °C.

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Activity 7.4: Let us observe and calculate

Let us now try to find the smallest value that a given laboratory thermometer can read.

- Again, take the same laboratory thermometer which you used in Activity 7.3 and observe it carefully.
- Note down the following:
  - How much is the temperature difference indicated between the two bigger marks? ----------
  - How many divisions (shown by smaller marks) are there between these two bigger marks? ----------
  - How much temperature does one small division indicate? ----------
  - So, the smallest value that the thermometer can read is ----------

Fig. 7.3b shows a closeup of a part of the thermometer shown in Fig. 7.3a. Can you now find the smallest value that this thermometer can read?



Fig. 7.3(b): Closeup of a part of the thermometer shown in Fig. 7.3a.

For the thermometer shown in Fig. 7.3b, the temperature difference indicated between 0 °C and 10 °C or between 10 °C and 20 °C is 10 °C. And the number of divisions between these marks are 10 divisions. So, one small division can read 10/10 = 1 °C.

That is, the smallest value that this thermometer can read is 1 °C.

Your school laboratory may have thermometers for which the range and the value of the smallest division may be different. It is, therefore, always necessary to look carefully at the thermometer you are about to use.

You have learnt how to find the temperature range of a given laboratory thermometer. You have also learnt how to find the smallest value that a given laboratory thermometer can read. We will now learn how to measure temperature using a laboratory thermometer. But, let us first learn how to use a laboratory thermometer correctly.

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Correct way of measuring temperature using a laboratory thermometer

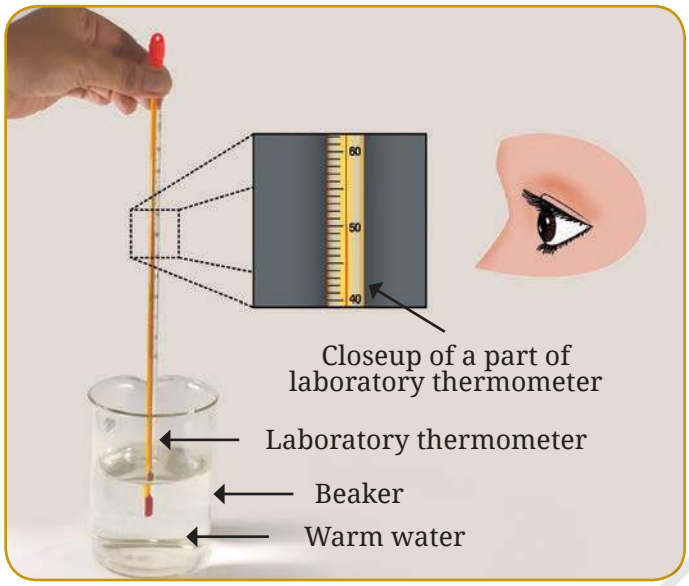


Fig.7.4: Measuring temperature of warm water

- When the thermometer is immersed in water, its bulb should not touch the bottom or the sides of the beaker.
- The thermometer should be held vertically (Fig. 7.4). It should not be tilted.
- The temperature must be read while the thermometer is immersed in water.
- While reading the thermometer, the eye should be directly in line with the level of the liquid column to be read (Fig. 7.4).

Activity 7.5: Let us measure

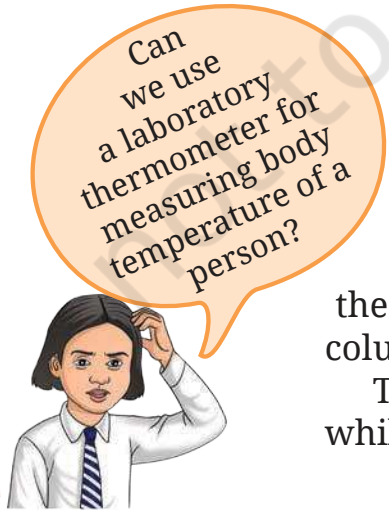
- Take some warm water in a beaker.
- Dip the thermometer in water so that the bulb is immersed in water (Fig. 7.4).
- Observe the rise of liquid column in the thermometer.

Wait till the column stops rising and note the temperature (do not wait too long; otherwise, the water itself will start to cool).

What is the temperature of water measured by you? Compare it with the readings of your friends.

Do you notice that, as soon as you take the thermometer out of the water, the level of liquid column begins to fall?

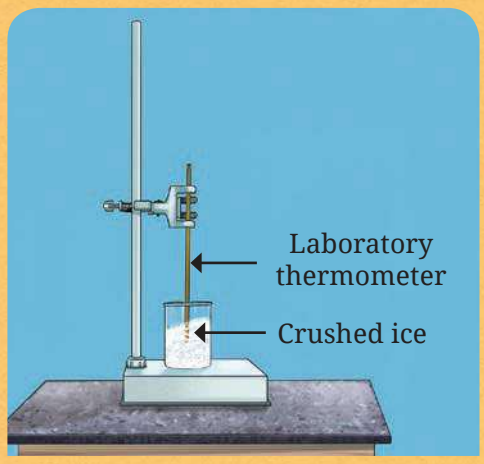
This means that the temperature must be read while the thermometer is immersed in water.

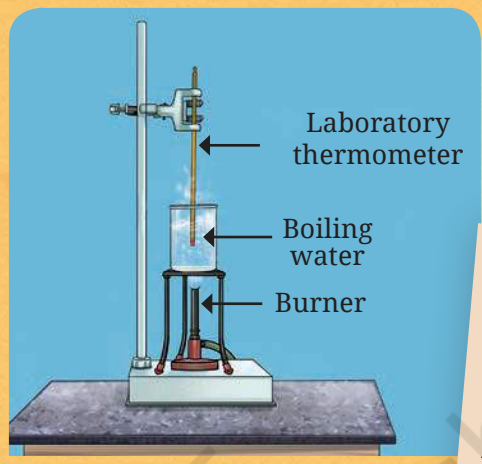


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More to do!

Following two experimental setups are to be arranged by your teacher. One by one, as per your turn, go closer to the setups and observe the readings of both the thermometers. What are the temperatures of ice and boiling water?





Read the temperatures of ice and boiling water again after some time. Are the temperatures same or have changed? You may have noticed that the temperature of water remains constant while it is boiling. Also, the temperature of ice remains constant while it is melting.

Caution
This activity should be performed strictly only under supervision of the teacher. Do not touch the experimental setups.

Activity 7.6: Let us compare

- Phiban's Science teacher arranged the experimental setup for measuring temperature of boiling water. The temperature readings of the boiling water taken by Phiban and her classmates in Shillong are given in Table 7.2.

Table 7.2: Temperature of boiling water

Name	Temperature of boiling water (in °C)
Phiban	97.8
Shemphang	98.0
Onestar	97.9
Kloi	98.0
Bandarisha	98.1

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- Compare the temperatures of boiling water recorded by different students.

Why are there differences in their readings? **Discuss** the possible reasons amongst yourselves. Maybe, the correct way of reading temperature was not followed by all the students.

7.3.3 Air temperature

You might have seen thermometers, such as the one shown in Fig. 7.5, hung on walls of your school laboratory, doctor's clinic, and hospitals. These give an approximate idea of the room temperature.

Have you seen weather reports in newspapers, TV news or internet? These reports also mention the maximum and minimum air temperature of the day.



Fig.7.5: Room thermometer

Activity 7.7: Let us analyse

- Read or listen to the weather reports for a place for 10 successive days.
- Record the maximum and minimum air temperature for each day in Table 7.3.
- Analyse the data in Table 7.3.

Table 7.3: Maximum and minimum air temperature

S.no.	Date	Maximum air temperature	Minimum air temperature
1.			
.			
.			
10.			

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Does the maximum and minimum temperature stay at the same level during these days?

Because weather depends on several factors, these temperatures usually vary every day. Generally, as we approach the summer season, the temperature rises and during the winter season it falls.

More to know!

There are many techniques for measuring air temperature. Air temperature is an important weather parameter and is monitored at weather stations all over the world. The data gathered on air temperature along with various other parameters are used for making weather forecasts.

Know a scientist

Anna Mani (1918–2001) was an Indian scientist, also known as the 'Weather Woman of India'. She invented and built a large number of weather measurement instruments. This reduced the reliance of India on other nations for such instruments. She also explored the possibilities of using wind and solar energy in India. Her work helped India to become one of the global leaders in renewable energy.



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Keywords

Air Temperature	Analyse
Celsius Scale	Calculate
Clinical thermometer	Compare
degree Celsius	Discuss
degree Fahrenheit	Infer
Fahrenheit scale	Investigate
kelvin	Measure
Kelvin scale	Observe
Laboratory thermometer	Precaution
SI unit of temperature	Predict
Temperature	Record

Summary

Key Points

- The temperature of a body tells us how hot or cold it is.
- The three most-used scales of temperature are: (a) the Celsius scale, (b) the Fahrenheit scale, and (c) the Kelvin scale. The units of temperature in these scales are (a) degree Celsius, denoted by °C, (b) degree Fahrenheit, denoted by °F, and (c) kelvin, denoted by K.
- The SI unit for temperature is kelvin.
- A clinical thermometer is used for measuring body temperature.
- Normal temperature of a healthy human adult is taken to be 37.0 °C or 98.6 °F.
- Laboratory thermometers typically have a temperature range from –10 °C to 110 °C.

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Let us enhance our learning

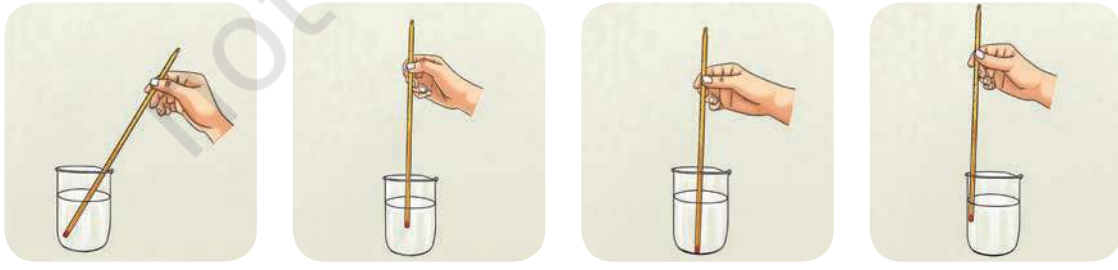
1. The normal temperature of a healthy human being is close to ---------- .
   (i) 98.6 °C
   (ii) 37.0 °C
   (iii) 32.0 °C
   (iv) 27.0 °C

2. 37 °C is the same temperature as ---------- .
   (i) 97.4 °F
   (ii) 97.6 °F
   (iii) 98.4 °F
   (iv) 98.6 °F

3. Fill in the blanks:
   (i) The hotness or coldness of a system is determined by its ---------- .
   (ii) The temperature of ice-cold water cannot be measured by a ---------- thermometer.
   (iii) The unit of temperature is degree ---------- .

4. The range of a laboratory thermometer is usually ---------- .
   (i) 10 °C to 100 °C
   (ii) –10 °C to 110 °C
   (iii) 32 °C to 45 °C
   (iv) 35 °C to 42 °C

5. Four students used a laboratory thermometer to measure the temperature of water as shown in Fig. 7.6:



Student 1 Student 2 Student 3 Student 4

Fig. 7.6

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Who do you think followed the correct way for measuring temperature?

(i) Student 1

(ii) Student 2

(iii) Student 3

(iv) Student 4

6. Colour to show the red column on the drawings of thermometers (Fig. 7.7) as per the temperatures written below:

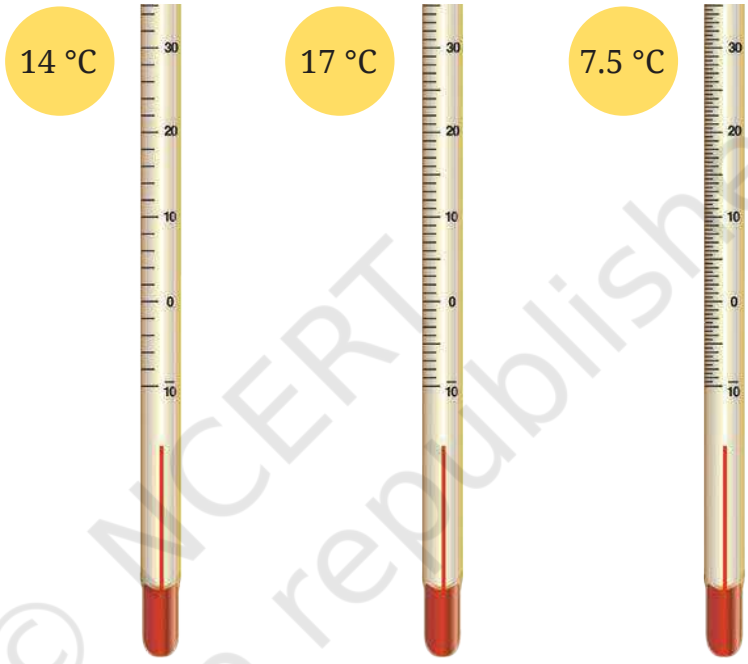


Fig. 7.7

7. Observe the part of thermometer shown in Fig. 7.8 and answer the following questions:



Fig. 7.8

(i) What type of thermometer is it?

(ii) What is the reading of the thermometer?

(iii) What is the smallest value that this thermometer can measure?

8. A laboratory thermometer is not used to measure our body temperature. Give a reason.

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9. Vaishnavi has not gone to school as she is ill. Her mother has kept a record of her body temperature for three days as shown in Table 7.4.

Table 7.4: Body temperature record of Vaishnavi

DAY	Temperature at					
	7am	10am	1pm	4pm	7pm	10pm
One	38.0 °C	37.8 °C	38.0 °C	38.0 °C	40.0 °C	39.0 °C
Two	38.6 °C	38.8 °C	39.0 °C	39.0 °C	39.0 °C	38.0 °C
Three	37.6 °C	37.4 °C	37.2 °C	37.0 °C	36.8 °C	36.6 °C

(i) What was Vaishnavi's highest recorded temperature?

(ii) On which day and at what time was Vaishnavi's highest temperature recorded?

(iii) On which day did Vaishnavi's temperature return to normal?

10. If you have to measure the temperature 22.5 °C, which of the following three thermometers will you use (Fig. 7.9)? Explain.

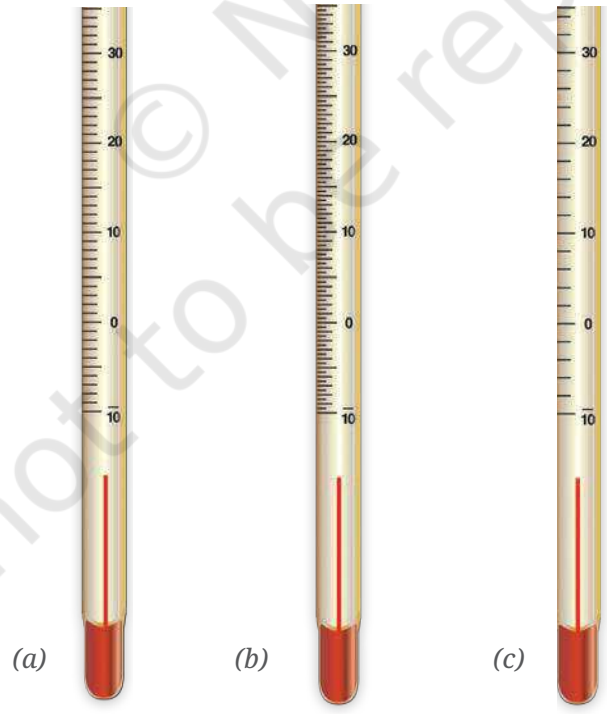


Fig. 7.9: Three thermometers

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11. The temperature shown by the thermometer in Fig. 7.10 is

(i) 28.0 °C
(ii) 27.5 °C
(iii) 26.5 °C
(iv) 25.3 °C

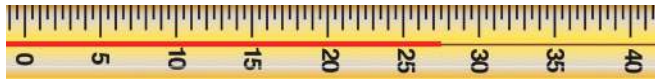


Fig. 7.10

12. A laboratory thermometer has 50 divisions between 0 °C and 100 °C. What does each division of this thermometer measure?

13. Draw the scale of a thermometer in which the smallest division reads 0.5 °C. You may draw only the portion between 10 °C and 20 °C.

14. Komal tells you that she has a fever of 101 degrees. Does she mean it on the Celsius scale or Fahrenheit scale?

Learning further

- Gather information from the Internet and find out how the body temperature of animals, such as a cat, dog, horse, camel, cow and buffalo, is measured. If there is any veterinary hospital in your vicinity, you may visit to see the body temperature of animals being measured.
- Find out which places in India are usually regarded to be the coldest and hottest. Also, find out the minimum and the maximum temperatures recorded for these places.
- Various planets in our Solar System are at different distances from the Sun. Search the Internet and make a table with the planets, their distances from the Sun (in increasing order) and their temperatures written. Does the average temperature of planets decrease as their distance from the Sun increases? If it is not true for any planet, find out for which planet and why.
- Hang a room thermometer in your classroom. Set up the apparatus, as shown in Fig. 7.11, near the thermometer hung on the wall.

  Take the readings of thermometers 1 and 2 three times during the day, say, first period, lunch break, and last period.

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Record your readings. Compare the readings and draw your conclusions. Repeat this for two weeks.

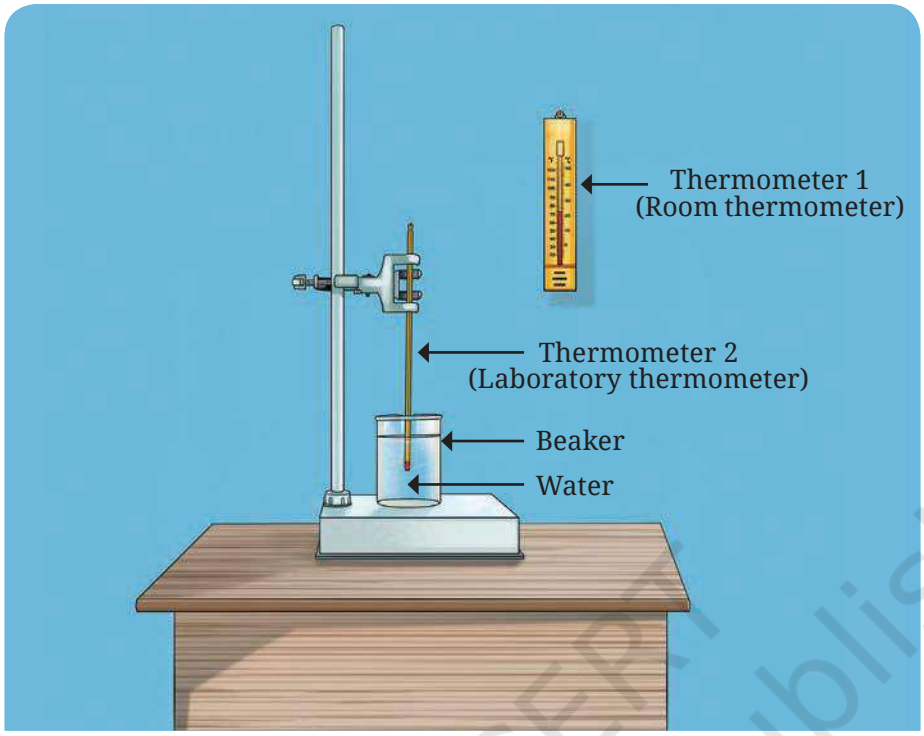


Fig. 7.11: Set up to measure temperature of water and room temperature

More to know!

The temperature at the core of the Sun reaches as high as 15 million degrees Celsius. Are there objects in the sky that have even higher temperatures? There is no limit on the highest temperature that can exist. However, as per scientific understanding, there is a limit to the lowest temperature that can be achieved. It is close to –273.15 °C (0 kelvin) and is called absolute zero.

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Notes

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