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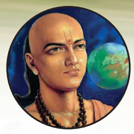


"To measure motion is to measure the rhythm of the universe." – **Aryabhata**

Measurement of Time and Motion

The Big Question

Have you ever wondered how Olympic athletes are timed so precisely that winners are decided by mere hundredths of a second? Or how, long before digital clocks and smartwatches, people managed to keep track of time? From the rhythmic swing of a pendulum to the incredible speed of a cheetah, the world around us is filled with motion and the constant passage of time. How do we make sense of these fundamental concepts?

Meet EeeBee.AI

A friendly, curious bee character named EeeBee, wearing a tiny lab coat and holding a magnifying glass. EeeBee is smiling and looks ready to explore.

Hello, young scientists! I'm EeeBee, your guide through the fascinating world of science. I love to buzz around, ask questions, and discover new things. In this chapter, we'll explore how we measure time and motion, from ancient inventions to modern marvels. Get ready to observe, think, and experiment with me!

Learning Outcomes

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

- **Understand:** the historical methods of time measurement.
- **Explain:** the working principle of a simple pendulum and its time period.
- **Identify:** the standard units of time and speed.
- **Calculate:** speed, distance, and time using appropriate formulas.

From Last Year's Notebook

- Measurement of length and length of curved line
- Moving thing and types of Motion

Science Around You

From catching a bus to timing a cake in the oven, or even understanding the speed of light in space communication, measuring time and motion is fundamental to our daily lives and technological advancements. It helps us plan our day, design faster vehicles, and even predict celestial events. Understanding these concepts is key to comprehending the world, from the smallest atomic vibrations to the grand movements of planets.

NCF Curricular Goals and Competencies

CG 8.1 – Learn to measure motion using speed, distance, and time.

CG 8.2 – Understand that time is measured using clocks and motion using tools like a stopwatch or scale.

Mind Map

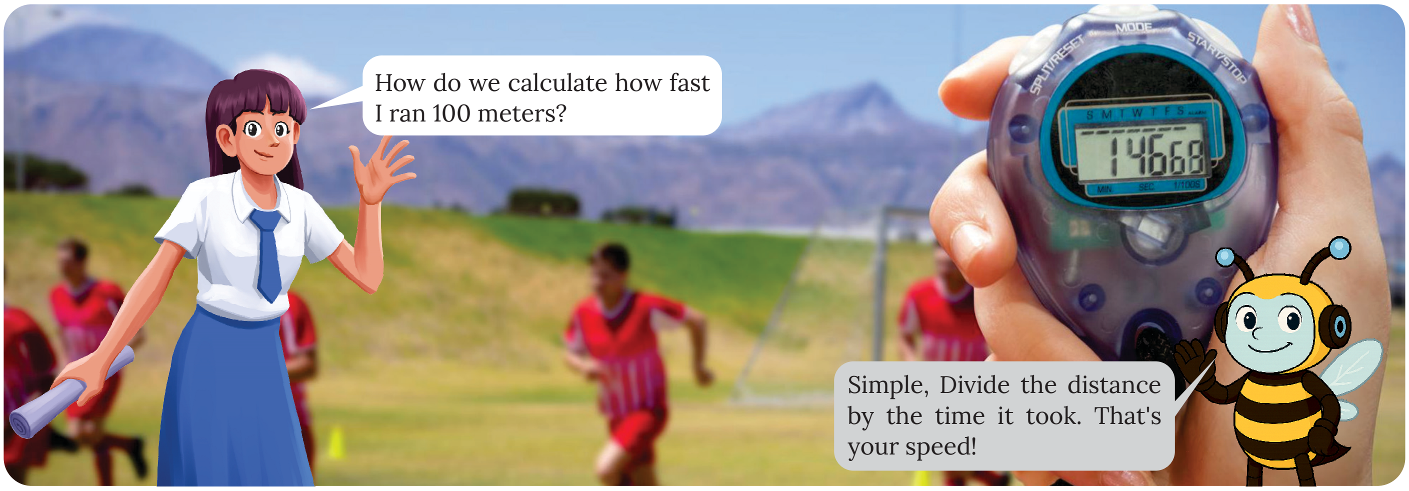
Measurement of Time and Motion

Measuring Time Through the Ages

- **Time** = measured using natural events & devices.
- **Ancient devices:** Sundial, Water clock, Hourglass, Candle clock.
- **Simple Pendulum:** Bob oscillates.
  - ✓ Time period (T) = time for one oscillation.
  - ✓ Depends on length (not mass).
- **Modern clocks:** Quartz (crystals), Atomic clocks (most accurate).
- **Units: SI** = second (s); 60s = 1 min; 60 min = 1h.

Types and Measurement of Motion

- **Motion** = change of position w.r.t. time.
- **Speed: Speed = Distance ÷ Time.**
  - ✓ SI unit = m/s; also km/h.
  - ✓ Distance = Speed × Time; Time = Distance ÷ Speed.
- **Types of motion:**
  - ✓ Uniform → Equal distances in equal intervals.
  - ✓ Non-uniform → Unequal distances in equal intervals.
- **Devices:** Speedometer (instant speed), Odometer (total distance).
- **Applications:** Sports, transport, medicine, technology, research.



In Focus

- Measuring Time Through the Ages
- Types and Measurement of Motion

Introduction

Time is a fundamental aspect of our existence, an invisible river flowing ceaselessly. But how did humanity track its relentless march before the invention of mechanical clocks? For millennia, people relied on the natural world and their own ingenuity to measure the passage of time. These early methods were often rooted in observations of celestial movements or the consistent flow of materials, leading to the creation of fascinating and surprisingly accurate devices.

From History's Pages

The late 19th century witnessed Eadweard Muybridge's pioneering chronophotography, analyzing animal and human motion frame-by-frame. In the early 20th century, Einstein's theories of relativity fundamentally altered our understanding of space and time, revealing their interconnectedness and dependence on relative motion. World War II spurred radar development, providing new means to measure object speed and distance precisely.

Measuring Time Through the Ages

Ancient Time-Measuring Devices

Before the precision of modern clocks, various clever instruments served as humanity's timekeepers, each leveraging a different natural phenomenon.

Sundials

A sundial is an ingenious instrument that uses the sun's shadow to tell time. It consists of a dial plate with marked hour lines and a projecting rod or plate called a gnomon, which casts the shadow. As the sun traverses the sky, the gnomon's shadow moves across the dial, indicating the time.

- **Principle:** Sundials measure solar time, which directly corresponds to the sun's apparent position. This time varies slightly throughout the year and depends on your geographical longitude.

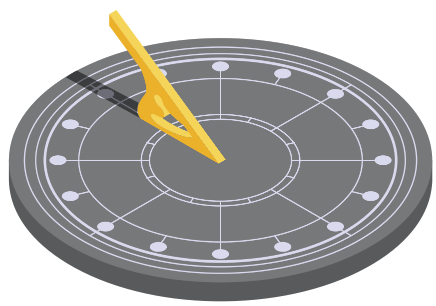


Fig. 8.1 Sundials

Example: The monumental **Samrat Yantra** at Jantar Mantar in Jaipur, India, is a prime example. Its shadow moves at approximately 1 millimeter per second, showcasing the incredible precision achievable by ancient astronomers.

- **Limitations:** Sundials are ineffective at night or on cloudy days. They also measure local apparent solar time, which differs from standardized clock time.

Water Clocks (Clepsydra)

Water clocks, or **clepsydras**, measure time by regulating the flow of water. Two primary types existed:

- **Outflow Type:** In this design, water steadily drains from a marked vessel. The decreasing water level indicates the elapsed time.
- **Inflow (Sinking Bowl) Type:** A bowl with a small hole was floated in a larger body of water. As water slowly seeped into the bowl, it would gradually fill and sink after a fixed interval. This type was known as 'Ghatika-yantra' in ancient India.
- **Scientific Principle:** The accuracy of outflow water clocks was limited because the water flow rate decreased as the vessel emptied due to reduced pressure. The sinking bowl method generally offered better consistency.

  Example: Ancient Egyptians, Greeks, and Chinese widely used water clocks. The **'Ghatika-yantra'** found purpose in Buddhist monasteries and royal palaces across India.
- **Limitations:** Their accuracy could be affected by external factors like water viscosity and temperature, leading to inconsistent flow rates.

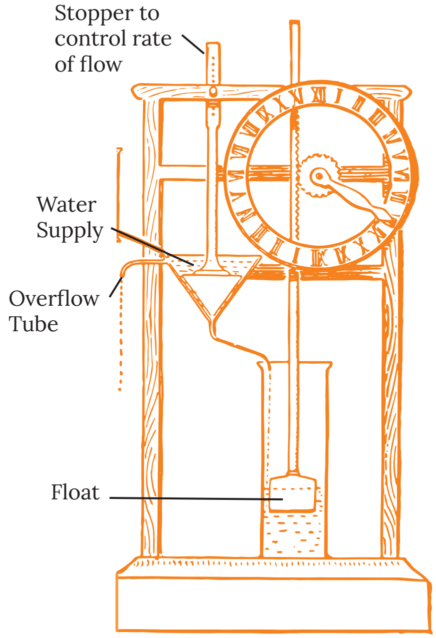


Fig. 8.2 (a) Water flowing out-type
(b) Floating bowl-type

Hourglasses

An hourglass consists of two glass bulbs connected vertically by a narrow neck. Sand flows from the upper bulb to the lower one at a regulated rate. Once all the sand has fallen, the hourglass is inverted to measure another fixed time interval.

- **Principle:** The relatively consistent flow rate of sand makes hourglasses more reliable for measuring specific durations than early water clocks.

  Example: Hourglasses were commonly used on ships to measure time at sea and in churches during sermons.
- **Limitations:** Hourglasses measure fixed time intervals and require manual resetting for continuous timekeeping. They don't track continuous time.

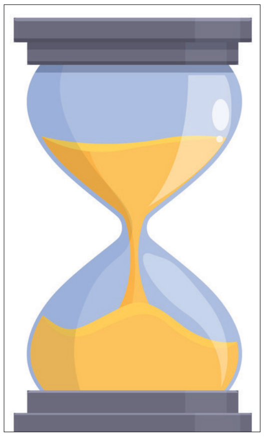


Fig. 8.3 Hourglasses

Candle Clocks

Candle clocks were simple timekeeping devices made from marked candles. As the candle burned down, the marks on its side indicated the passage of specific time intervals.

- **Principle:** Their accuracy depended entirely on the consistency of the candle's burning rate.

Keywords

Ghatika-yantra: It was an ancient Indian water clock used to measure time accurately. It worked by the controlled flow of water, marking the passage of hours.

Example: King Alfred the Great of England is famously said to have used candle clocks in the 9th century.

- **Limitations:** Factors like drafts, variations in wax composition, and wick quality could significantly affect the burning rate, limiting their precision.

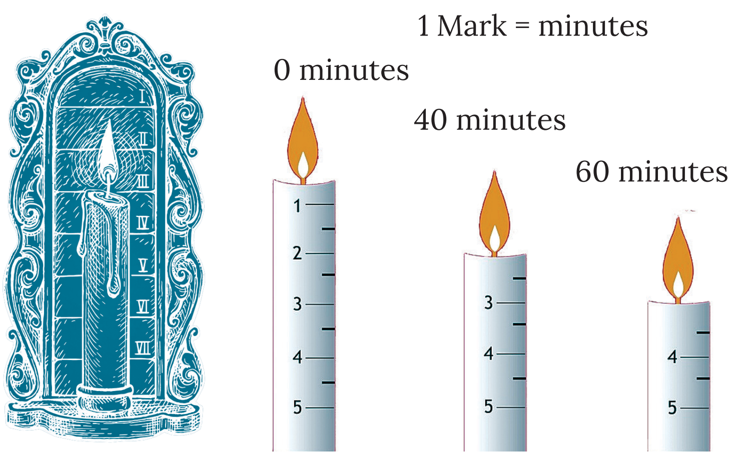


Fig. 8.4 A Candle Clock

The Simple Pendulum: A Foundation for Accurate Timekeeping

The invention of the pendulum clock marked a monumental leap in precise time measurement. At its heart lies the simple pendulum, a device whose regular, periodic motion provides a remarkably consistent rhythm.

What is a Simple Pendulum?

A simple pendulum consists of a small, heavy metallic ball, known as the bob, suspended from a rigid support by a long, light, and inextensible thread. When displaced from its resting position and released, the bob swings back and forth in a repetitive arc.

Understanding the motion of a simple pendulum involves several key terms:

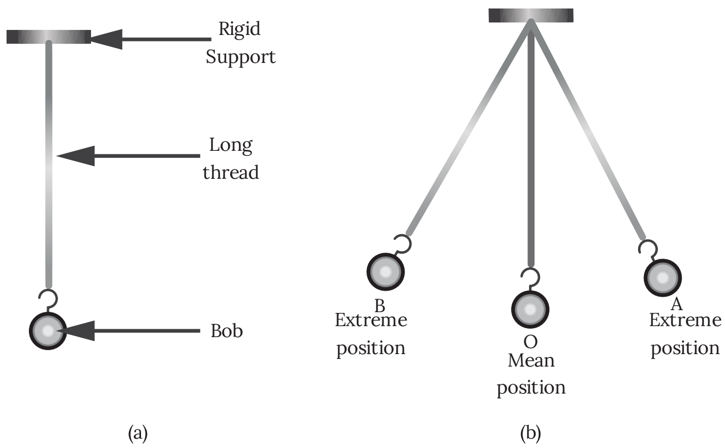


Fig. 8.5 A Simple Pendulum

- **Mean Position (Equilibrium Position):** This is the central, resting position of the pendulum bob when it is not swinging.
- **Extreme Positions:** These are the furthest points the bob reaches on either side of its mean position during its swing.
- **Oscillation:** One complete back-and-forth motion of the pendulum. This can be defined in two ways:
  - From the mean position (O), to one extreme (A), then to the other extreme (B), and back to the mean position (O).
  - From one extreme position (A), to the other extreme (B), and then back to the first extreme position (A).
- **Periodic Motion:** The motion of a simple pendulum is periodic because it repeats itself precisely after a fixed interval of time.
- **Time Period (T):** This is the time taken by the pendulum to complete one full oscillation. Crucially, for a simple pendulum of a given length, its time period remains remarkably constant at a particular location, making it ideal for timekeeping.

Fig. 8.6 Pendulum Clocks

Modern Clocks: The Pinnacle of Precision

The journey of timekeeping has reached astonishing levels of precision with the advent of modern clocks. These devices leverage highly stable and precise periodic processes, far surpassing the accuracy of their mechanical predecessors.

Quartz Clocks

Quartz clocks utilize the remarkably regular vibrations of a quartz crystal to keep time. When an electric current is applied to a quartz crystal, it vibrates at an extremely precise and consistent frequency. This stable frequency acts as the clock's "heartbeat," which is then used by electronic circuits to count the vibrations and display the time.

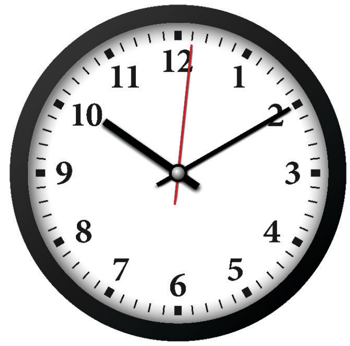


Fig. 8.7 Quartz Clocks

Example: Most everyday timekeeping devices, such as digital wristwatches, wall clocks, and many electronic gadgets, are powered by quartz crystals.

- **Significance:** They offer significantly greater accuracy than mechanical clocks, making reliable timekeeping accessible for daily use.

Atomic Clocks

Atomic clocks represent the pinnacle of modern timekeeping accuracy. Instead of a mechanical or crystal oscillator, they rely on the incredibly precise and stable resonant frequencies of atoms, such as Cesium or Rubidium. The quantum vibrations of these atoms are extraordinarily consistent and form the very definition of the second in the International System of Units (SI).

Fig. 8.8 Cesium Atomic Clock

Example: Atomic clocks are indispensable for critical modern technologies, including GPS (Global Positioning System) satellites, which rely on their precise timing to determine location, and the synchronization of global communication networks.

- **Significance:** These are the most accurate timekeeping devices known, capable of losing only about one second in millions of years. They form the fundamental basis for international time standards (like Coordinated Universal Time, UTC) and are crucial for scientific research requiring extreme precision.

The SI Unit of Time: The Second

In the world of science and engineering, clear and consistent measurement is paramount. The International System of Units (SI) provides a standardized framework for all fundamental physical quantities, and time is no exception.

- **Definition:** The fundamental SI unit of time is the second (s).
- **Significance:** All other units of time, whether smaller (like milliseconds) or larger (like minutes or hours), are defined in relation to the second. Modern atomic clocks are so precise that they are used to define the length of a second with incredible accuracy, anchoring our global time standards.

Common Units and Conversions:

While the second is the base unit, we often use larger units for convenience:

- Minute (min): 1 minute = 60 seconds
- Hour (h): 1 hour = 60 minutes = 3600 seconds

Fact Flash

Ancient India utilized both shadow and water clocks for timekeeping. Early references to shadow-based measurement and outflow water clocks appear in the Arthasastra (2nd BCE – 3rd CE). Varahamihira provided accurate shadow expressions around 530 CE. The less accurate outflow clocks led to the development of the sinking bowl water clock (Ghatika-yantra), first noted by Aryabhata. Ghatika-yantra were widely used and announced by sound, persisting in religious rituals even after 19th-century pendulum clock adoption.

Common Misconceptions

× **Misconception:** The time period of a simple pendulum depends on how heavy the bob is.

✓ **Correction:** For small angles of swing, the time period of a simple pendulum is almost independent of the mass of the bob. It primarily depends on the length of the pendulum and the acceleration due to gravity at that location.

× **Misconception:** All clocks measure time with the same level of accuracy.

✓ **Correction:** Different types of clocks have vastly different levels of accuracy. Mechanical clocks are less accurate than quartz clocks, which in turn are far less accurate than atomic clocks. The precision required dictates the type of clock used.

Science Around You

In today's world, precise time measurement is crucial, impacting various fields. From sports, where winners are decided by milliseconds, to medicine, with ECG machines detecting heartbeat variations in milliseconds, and digital music recordings capturing thousands of samples per second, accuracy is key. Even faster, smartphones and computers process signals in microseconds, showcasing how increasingly precise timekeeping tools drive societal advancements that often go unnoticed.

Activity

Measuring a Simple Pendulum's Time Period

Objective: Understand and measure the time period of a simple pendulum.

- **Materials:**
  - String (approx. 150 cm)
  - Small, heavy metallic ball/stone (bob)
  - Rigid support (clamp stand/hook)
  - Stopwatch, Ruler/measuring tape

Fig. 8.9 *Materials Required*

- **Procedure:**
  1. **Set Up:** Tie bob to string. Hang from support. Adjust length to 100 cm (point of suspension to bob's center). Ensure free swing.
  2. **Mean Position:** Let bob hang still.
  3. **Start Swing:** Gently pull bob slightly (5-10 cm) to one side; release (do not push).
  4. **Measure 20 Oscillations:** As bob passes mean position, start stopwatch. Count 20 complete back-and-forth swings.
  5. **Record Time:** Stop stopwatch on 20th oscillation. Record total time.
  6. **Calculate Time Period:** Divide total time by 20.
     - Time Period (T) = Total Time / 20
  7. **Repeat & Average:** Do steps 3-6 twice more. Calculate average time period.
  8. **Investigate Length:** Repeat activity with different string lengths (e.g., 80 cm, 60 cm).

Observations: The time period for a given length is nearly constant. Longer pendulums have longer time periods. The bob's mass has little effect (for small swings).

Knowledge Checkpoint

Gap Analyzer™ Homework

Watch Remedial

Multiple Choice Questions:

Remembering

1. Which of the following ancient time-measuring devices relies on the consistent flow of sand?
   - a) Sundial ☐
   - b) Water Clock ☐
   - c) Hourglass ☐
   - d) Candle Clock ☐
2. What is the SI unit of time?
   - a) Minute ☐
   - b) Hour ☐
   - c) Second ☐
   - d) Day ☐

Applying

3. A simple pendulum completes 20 oscillations in 40 seconds. What is its time period?
   - a) 0.5 s ☐
   - b) 2 s ☐
   - c) 20 s ☐
   - d) 40 s ☐

Understanding

Short Answer Question:

4. Explain why sundials are not suitable for measuring time at night or on cloudy days.
5. What is an oscillation of a simple pendulum? Describe two ways to define one complete oscillation.

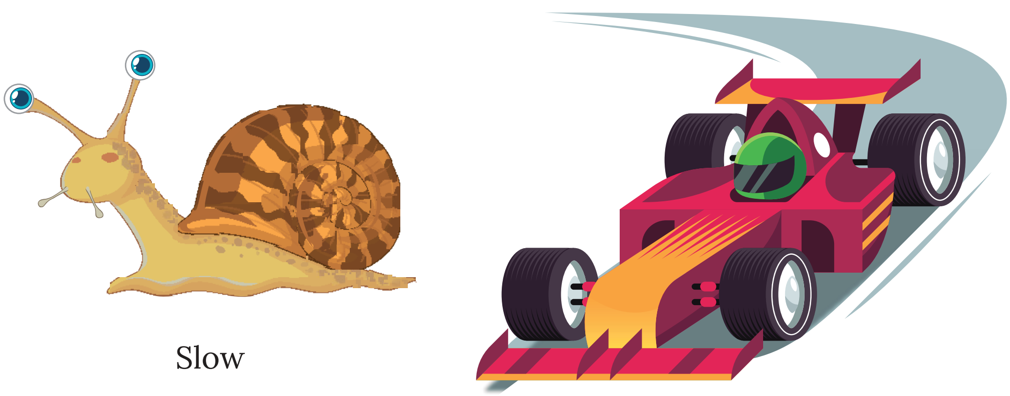
Evaluating

Long Answer Question:

6. Discuss the significance of the simple pendulum's constant time period in the development of accurate timekeeping devices. How did this property lead to a major breakthrough compared to earlier methods?

Types and Measurement of Motion

When we observe objects in motion, we instinctively describe them as "slow" or "fast." A snail moves slowly, while a racing car moves fast. But how do we quantify this "slowness" or "fastness"? What exactly determines if one object is moving faster than another? This section introduces the fundamental concept of speed, which provides a scientific way to compare how quickly objects cover distance. We will learn how to calculate speed, understand its units, and explore the relationship between speed, distance, and time. We will also differentiate between uniform and non-uniform motion.



Slow

Fast

Fig. 8.10 A Types and Measurement of Motion

Types of Linear Motion

1. Uniform Linear Motion

- An object is said to be in uniform linear motion if it moves along a straight line and covers equal distances in equal intervals of time.
- In this case, the speed remains constant.

Example: 1. A car moving on a straight highway at a steady speed of 60 km/h.

2. The second hand of a clock moving at a constant speed along the circular edge (linear distance per second is same).

2. Non-uniform Linear Motion

- An object is in non-uniform linear motion if it moves along a straight line but covers unequal distances in equal intervals of time.
- Here, the speed keeps changing — it may increase, decrease, or vary irregularly.

Example: 1. A car moving in traffic: sometimes slow, sometimes fast.

2. A ball rolling on the ground and gradually slowing down due to friction.

Comparison Table

Feature	Uniform Linear Motion	Non-uniform Linear Motion
Path	Straight line	Straight line
Distance covered in equal time intervals	Equal	Unequal
Speed	Constant	Changing (increasing or decreasing)
Example	Car at steady speed	Car in traffic

Speed

- Speed tells us how fast an object is moving. In science, it is defined as the distance travelled by an object in a given unit of time.
- If an object covers more distance in the same time, it is moving faster.
- If an object covers the same distance in less time, it is also moving faster.
- **In simple words:** Greater distance in less time means greater speed.

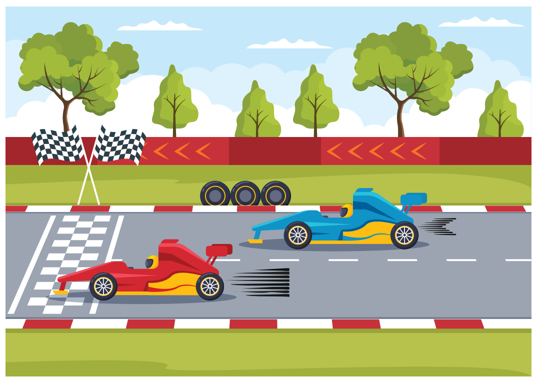


Fig. 8.11 Understanding Speed

Calculating Speed

- Speed is calculated by dividing the total distance covered by the total time taken to cover that distance.
- **Formula:** $\text{Speed} = \frac{\text{Total Distance Covered}}{\text{Total time take}}$

Example: If a car travels 120 km in 2 hours, its speed is :

$$\text{Speed} = \frac{120\text{km}}{2\text{h}} = 60\text{km}/\text{h}$$

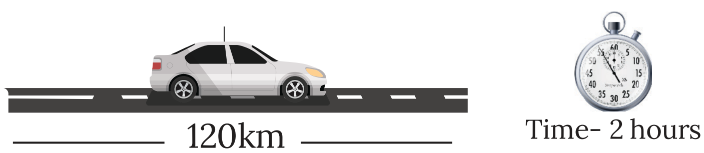


Fig. 8.12 Calculating Speed

Units of Speed

- The units of speed are derived from the units of distance and time.
- **SI Unit:** The SI unit of speed is **metre per second (m/s)**, derived from the SI unit of distance (metre) and time (second).
- **Other Common Units:** **kilometre per hour (km/h)** is widely used for vehicles. Centimetre per second (cm/s) might be used for very slow movements.

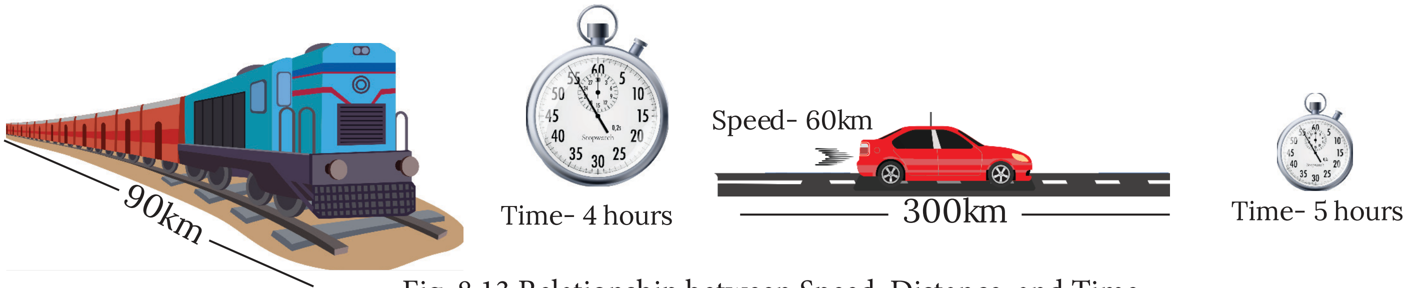


Fig. 8.13 Relationship between Speed, Distance, and Time

- The fundamental relationship can be rearranged to find any of the three quantities if the other two are known.
- **To find Distance:** Total distance covered = Speed × Total time taken
- **To find Time:** Total time taken = Total distance covered / Speed

Speedometer and Odometer

These are instruments found in vehicles that provide information about motion.

- **Speedometer:** An instrument that measures and displays the instantaneous speed of a vehicle, usually in km/h or mph.
- **Odometer:** An instrument that measures and displays the total distance travelled by a vehicle, usually in kilometres or miles.

  Examples: Look at the dashboard of a car or scooter; you will see both a speedometer and an odometer.

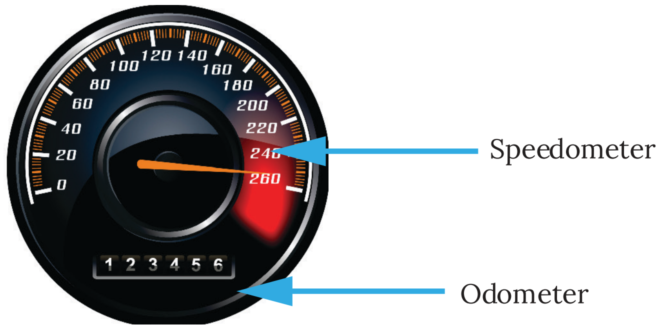


Fig. 8.14 Speedometer and Odometer

Example:

1. A train travels from Station A to Station B, a distance of 300 km, in 4 hours. Find the speed of train.

   Solution:

   Given:

   ✦ Distance = 300km

   ✦ Time = 4 hours

   $$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

   $$\text{Speed} = \frac{300\text{km}}{4\text{h}}$$

   Speed = 75 km/h

2. A cyclist maintains an average speed of 20 km/h for 3.5 hours. Find distance covered by cyclist.

   Solution:

   Given:

   ✦ Speed = 20km/h

   ✦ Time = 3.5 hours

   Distance = Speed × Time

   Distance = 20 km/h × 3.5 h

   = 70 km

3. A car travels at a constant speed of 25 m/s. How far will it travel in 1.5 hours? Give your answer in kilometers.

   Solution:

   Given:

   ✦ Speed = 25 m/s

   ✦ Time = 1.5 hours

   ✦ Conversion:

   ✦ Time: 1.5 hours × 60hour min × 60mins = 5400 s

   Calculation:

   ✦ Distance = Speed × Time

   ✦ Distance = 25sm × 5400 s = 135000 m

   Convert to kilometers:

   ✦ Distance = 135000 m ÷ 1000kmm = 135 km

4. A bullet train needs to cover a distance of 600 km. If its average speed is 80 m/s, how long will it take to reach its destination? Give your answer in hours and minutes.

Solution:

- ✦ Distance = 600 km = 600,000 m
- ✦ Speed = 80 m/s
- ✦ Time = Distance ÷ Speed

  = 600,000 ÷ 80

  = 7,500 seconds

Now,

1 minute = 60 seconds

So, 7,500 ÷ 60 = 125 minutes

= 2 hours 5 minutes

Answer: The bullet train will take 2 hours 5 minutes to reach its destination.

5. A hiker walks 4 km in the first 45 minutes and then rests for 15 minutes. After the rest, she walks another 3 km in 30 minutes. Calculate her average speed for the entire journey (excluding the rest period from calculation of total walking time) in km/hr.

Solution:

Total Distance Travelled

= 4 km + 3 km = 7 km

Total Walking Time

= 45 minutes + 30 minutes

= 75 minutes

Convert time to hours:

75 ÷ 60 = 1.25 hours

Average Speed

= Total Distance ÷ Total Time

= 7 ÷ 1.25

= 5.6 km/hr

Answer: The hiker's average speed is 5.6 km/hr.

6. A family is travelling in their car to visit relatives in another city. The driver maintains a constant speed of 72 km/h on the highway. If they travel continuously for 25 minutes without stopping, how much distance will they have covered during this time? Express your answer in kilometres.

Solution:

- ✦ Speed of the car = 72 km/h
- ✦ Time = 25 minutes

Convert time into hours:

25 ÷ 60 = 0.416 hours

Now,

- ✦ Distance = Speed × Time

  = 72 × 0.416

  ≈ 29.95 km

Answer: The family will cover approximately 30 km in 25 minutes.

7. An express train leaves the central railway station at exactly 10:00 AM and heads towards a nearby city at a uniform speed of 96 km/h. The distance between the two cities is 288 km. Assuming the train does not stop anywhere along the route, at what exact time will the train reach its destination?

Solution:

- ✦ Distance to be covered = 288 km
- ✦ Speed of the train = 96 km/h

Time = Distance ÷ Speed

= 288 ÷ 96

= 3 hours

Now, departure time = 10:00 AM

So, arrival time = 10:00 AM + 3 hours

= 1:00 PM

Answer: The express train will reach the destination at 1:00 PM.

Fact Flash

Even when you are sitting perfectly still, you are in constant motion! The Earth rotates on its axis at approximately 1,670 km/h at the equator and orbits the Sun at about 107,000 km/h. Furthermore, our entire solar system is orbiting the center of the Milky Way galaxy at a staggering 792,000 km/h.

Common Misconceptions

× **Misconception:** Speed and velocity are the same thing.

✓ **Correction:** Speed is a scalar quantity, meaning it only has magnitude (e.g., 50 km/h). Velocity is a vector quantity, meaning it has both magnitude and direction (e.g., 50 km/h North). While a car's speed might be constant, its velocity changes if it turns a corner.

× **Misconception:** If an object is moving, it must have a constant speed.

✓ **Correction:** Most real-world motion is non-uniform, meaning the speed changes over time (e.g., a car accelerating, a ball rolling downhill). Constant speed (uniform motion) is an idealization.

Science Around You

In automotive safety, accelerometers and gyroscopes measure sudden changes in motion (acceleration and rotation) to deploy airbags. In robotics, highly accurate sensors and control systems measure and regulate robotic arm movements in industrial assembly lines with micron-level precision. Global Positioning Systems (GPS) utilize precise timing and the known speed of radio signals from satellites to determine location and motion on Earth.

Activity

Measuring Your Walking Speed

Objective: Calculate your average walking speed and understand the relationship between distance, time, and speed.

Materials: Measuring tape (or long ruler), Stopwatch (or phone app), Clear, flat path

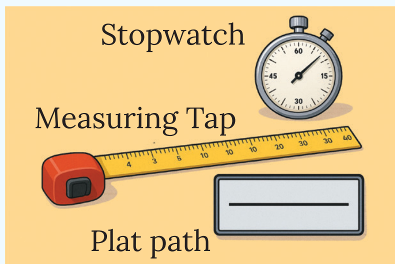


Fig. 8.15 Materials Required

- **Procedure:**
  1. Mark a 50m or 100m straight path with start and finish lines.
  2. Start walking at a normal pace when your partner says "Go" and starts the stopwatch.
  3. Stop the stopwatch as you cross the finish line.
  4. Record the distance and time taken.
  5. Repeat the walk two more times.
  6. Calculate average time.

  Find speed using: Speed = Total Distance ÷ Average Time

  Observation: You'll find your average walking speed and observe how it changes with effort or conditions, applying the speed = distance/time formula in real life.

Knowledge Checkpoint

Gap Analyzer™ Homework

Watch Remedial

Multiple Choice Questions:

Applying

1. A car travels 240 km in 4 hours. What is its average speed?
   a) 60 km/h b) 40 km/h
   c) 240 km/h d) 960 km/h

Remembering

2. Which of the following units is NOT a standard unit for speed?
   a) m/s b) km/h
   c) cm/s d) s/m

Analyzing

3. An object covers 10 meters in the first 2 seconds, 15 meters in the next 2 seconds, and 20 meters in the final 2 seconds. What type of motion is this?
   a) Uniform linear motion b) Non-uniform linear motion
   c) Circular motion d) Oscillatory motion

Short Answer Question:

Applying

4. Define speed and state its SI unit.
5. A bus travels at a speed of 72 km/h. Convert this speed to m/s.

Long Answer Question:

Analyzing

6. Differentiate between uniform linear motion and non-uniform linear motion. Provide a real-world example for each, explaining why it fits the definition.

SUMMARY

Measurement of Time:

- Humans have always sought to measure time, initially using natural repeating events like the rising and setting of the Sun, and phases of the Moon.
- **Ancient Time-Measuring Devices:** Included sundials (using shadows), water clocks (using water flow), hourglasses (using sand flow), and candle clocks (using burning candles). These had varying degrees of accuracy and limitations.
- **The Simple Pendulum:** consists of a bob suspended by a thread. Its back-and-forth motion is called **oscillation**.
- The **time period** of a simple pendulum is the time taken for one complete oscillation. A key discovery was that for a given length, its time period is nearly constant, leading to the invention of accurate pendulum clocks. The time period depends on its length but not on the bob's mass (for small swings).
- **Modern Clocks:** like quartz clocks (using vibrating quartz crystals) and atomic clocks (using precise atomic vibrations) offer extremely high accuracy, essential for modern technology.
- The **SI unit of time is the second (s)**. Larger units are minute (min) and hour (h), with 60 s = 1 min and 60 min = 1 h.

Types and Measurement of Motion:

- **Speed** is a measure of how fast an object is moving. It is defined as the distance covered by an object in a unit interval of time.
- **Formula for Speed:** Speed = Total distance covered / Total time taken.
- The **SI unit of speed is metres per second (m/s).** Kilometres per hour (km/h) is another common unit.
- The relationship between speed, distance, and time can be rearranged:
- Total distance covered = Speed × Total time taken
- Total time taken = Total distance covered / Speed
- **Uniform Linear Motion:** Occurs when an object moves along a straight line and covers equal distances in equal intervals of time (constant speed).
- **Non-uniform Linear Motion:** occurs when an object moves along a straight line and covers unequal distances in equal intervals of time (changing speed). Most real-world motion is non-uniform.
- **Speedometers:** Measure the instantaneous speed of a vehicle, while **odometers** measure the total distance travelled.
- Accurate measurement of time and motion is crucial in sports, transportation, medicine, technology, and scientific research.

Example Based Questions

Multiple Choice Questions

1. **Which of the following was one of the earliest devices used to measure time?**

   (a) Digital clock (b) Water clock
   (c) Wristwatch (d) Mobile phone

   Answer: (b) Water clock

   Explanation: Ancient civilizations used **sundials, water clocks, and sand clocks (hourglasses)** to measure time before mechanical and digital clocks were invented.

2. **Which of the following is an example of periodic motion?**

   (a) A child sliding down a slide
   (b) A car moving on a straight road
   (c) The pendulum of a clock
   (d) A man walking in a park

   Answer: (c) The pendulum of a clock

   Explanation: Periodic motion repeats itself at regular intervals. A pendulum swings back and forth regularly, making it a classic example of periodic motion.

Short Answer Questions

3. **How was time measured in ancient days before clocks were invented?**

   Answer: In ancient times, people measured time using natural events and simple devices:

   - **Sundials:** Used shadows cast by the Sun.
   - **Water clocks:** Measured time using the flow of water.
   - **Hourglasses:** Used sand trickling between two chambers.

   These methods, though less accurate, helped in farming, rituals, and daily activities.

4. **What is the difference between uniform and non-uniform motion? Give one example of each.**

   Answer: Uniform Motion: An object covers equal distances in equal intervals of time. Example: A train moving at a constant speed of 60 km/h.

   Non-Uniform Motion: An object covers unequal distances in equal intervals of time. Example: A car in traffic that keeps slowing down and speeding up.

   This distinction helps in studying movement scientifically.

5. **Why is accurate measurement of time important in today's world?**

   Answer: Accurate time measurement is essential for:

   - Running trains, flights, and buses on schedule.
   - Scientific experiments where seconds matter.
   - Sports events to record exact performance times.
   - Daily life activities like studying, cooking, and working.

   Modern atomic clocks provide extremely precise time to seconds, used even in GPS.

Long Answer Questions

6. **Explain different types of speed with examples from daily life.**

   Answer: Speed is the distance covered by an object in a given time. It can be of different types:

   1. **Uniform Speed: Definition:** An object is said to have uniform speed if it covers equal distances in equal intervals of time, no matter how small the intervals are.

      Example: A car moving steadily at 60 km/h.

   2. **Non-uniform Speed: Definition:** An object is said to have non-uniform speed if it covers unequal distances in equal intervals of time.

      Example: A bus moving in city traffic.

   3. **Average Speed: Definition:** Average speed is the total distance travelled divided by the total time taken, regardless of variations in speed during the journey.

      Example: A cyclist covering 30 km in 2 hours → average speed = 15 km/h.

Gap Analyzer™
Complete Chapter Test

EXERCISE

A. Choose the correct answer.

1. Which of the following is the SI unit of time?
   (a) Minute (b) Hour
   (c) Second (d) Day
2. A child riding a bicycle slows down while going uphill and speeds up while going downhill. This is an example of:
   (a) Uniform motion (b) Non-uniform motion
   (c) Rest (d) Circular motion
3. The type of motion observed in a car moving on a straight road at a constant speed is:
   (a) Oscillatory motion (b) Non-uniform motion
   (c) Uniform linear motion (d) Rotational motion
4. Which of the following devices is considered the most accurate for measuring time?
   (a) Sundial (b) Pendulum clock
   (c) Quartz watch (d) Atomic clock
5. If an object covers unequal distances in equal intervals of time, its motion is described as:
   (a) Uniform motion (b) Periodic motion
   (c) Non-uniform motion (d) Oscillatory motion

B. Fill in the blanks.

1. A sundial shows the time of the day by the position of the shadow cast by the _______.
2. A water clock measures time by the steady flow of _______ from one container to another.
3. Speed is calculated as _________ divided by time.
4. The unit symbol for a minute is _________, and for an hour is _________.
5. A car moving at a constant speed along a curved path exhibits _________ motion.

C. Write True or False.

1. A sundial can be used to measure time accurately at night. _________
2. The mean position of a pendulum is its furthest point from the center. _________
3. Atomic clocks are used to define the international standard of the second. _________
4. If an object covers equal distances in equal intervals of time, it is said to be moving with uniform speed. _______.
5. A swinging playground swing exhibits oscillatory motion. _________

D. Define the following terms.

1. Atomic clock
2. Time Period (of a pendulum)
3. Speed
4. Uniform Motion
5. Mean Position (of a pendulum)

E. Match the columns.

	Column A		Column B
1.	Sundial	(a)	Modern timekeeping device
2.	Atomic Clock	(b)	Ancient time measurement
3.	Oscillatory Motion	(c)	m/s or km/h
4.	Speed	(d)	Periodic motion
5.	Water Clock	(e)	Precise definition of the second

F. Assertion and Reason

Directions: In the following questions, a statement of assertion (A) is followed by a statement of reason (R). Mark the correct choice as:

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is NOT the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.
(e) Both A and R are false.

1. **Assertion (A):** The time period of a simple pendulum of a given length is constant at a particular location.
   Reason (R): The time period of a simple pendulum does not depend on the mass of the bob.
2. **Assertion (A):** Modern quartz clocks are much more accurate than pendulum clocks.
   Reason (R): Quartz crystals vibrate at a very precise frequency when an electric current is passed through them.
3. **Assertion (A):** A train moving out of a station exhibits uniform motion.
   Reason (R): Uniform motion is defined as covering equal distances in equal intervals of time.

G. Give reasons for the following statements.

1. Sundials cannot be used at night to measure time.
2. A car moving on a busy road is said to be in non-uniform motion.
3. The second hand of a clock shows uniform motion.
4. If two cars cover the same distance but in different times, their speeds are different.
5. A faster runner covers more distance than a slower runner in the same time.

H. Answer in brief.

1. What is the difference between uniform and non-uniform motion? Give one example of each.
2. How does an hourglass measure time?
3. How do quartz watches keep time accurately?
4. What is one oscillation of a pendulum? Mention two ways to define it..

I. Answer in detail.

1. Compare ancient time-measuring devices (like sundials and water clocks) with modern devices such as quartz clocks in terms of working principle and accuracy.
2. Define speed. Derive the relationship between speed, distance, and time with an example from daily life.
3. Why is the concept of average speed important when the motion of an object is non-uniform? Support your answer with an example.

SKILL-BASED PRACTICE

Activity Time

STEM

Measuring Pendulum Time Periods

Materials Needed: String (about 1 meter), Small metal bob, Stand with a clamp, Stopwatch, Ruler

Task / Problem : You are asked to investigate what factors affect the time period of a simple pendulum. The "time period" is the time taken for one complete oscillation.

Materials Required

Activity Steps:

1. Tie the bob to one end of the string and fix the other end to the clamp stand.
2. Pull the bob slightly to one side (small amplitude) and release it.
3. Use the stopwatch to measure the total time for **20 oscillations**.
4. Divide the total time by 20 to calculate the time period for one oscillation.
5. Repeat the experiment by:
   - o Changing the **length of the pendulum** (e.g., 30 cm, 50 cm, 70 cm, 90 cm).
   - o Using different **masses for the bob** (if available).

Questions to Answer:

1. How does the time period vary with the length of the pendulum?
2. Does changing the mass of the bob make a significant difference to the time period (for small amplitudes)?
3. What does this experiment suggest about the key factor(s) controlling a pendulum's motion?

Skills Covered: Experimentation, Data Collection & Analysis, Observation, Understanding variables

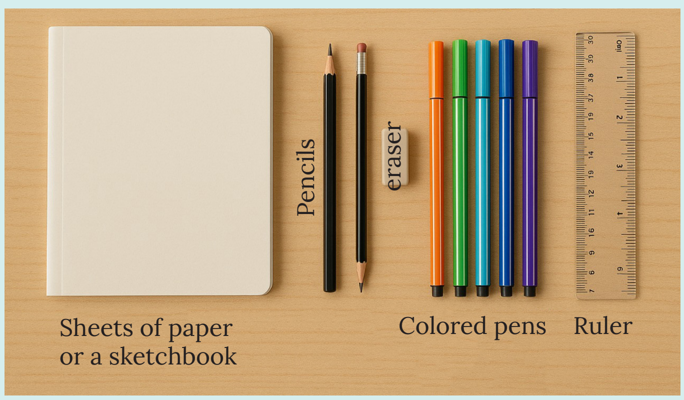
Creativity

Art

Motion Storyboard

Task: Design a visual storyboard (like a comic strip) showing how different kinds of motion appear in your daily life. Start with morning activities and move through the day—traveling to school, playing, studying, and finally bedtime. Each panel should illustrate and label one type of motion (e.g., linear, circular, periodic, oscillatory, random).

Materials to Use: Sheets of paper or a sketchbook, Pencils, erasers, Colored pens, sketch pens, or markers, Ruler (for neat panels or frames)



Materials Required

Steps to Follow

1. Divide your page into 6–8 panels, like a comic strip or storyboard.
2. In each panel, draw a scene from your daily routine that shows a type of motion (for example: brushing teeth, swing in the park, fan blades turning, a ball rolling, walking, cycling, pendulum in a clock).
3. Label the panel with the type of motion and add short notes or speech bubbles if you like.
4. Add color and creativity to make your storyboard lively and easy to understand.

Questions to Answer:

1. Which five types of motion did you highlight in your storyboard?
2. Did you notice some motions repeating often in your daily life? Which ones?
3. How did creating this storyboard help you see motion as part of science rather than just everyday routine?

Skills Covered: Creativity, Visual Communication, Conceptual Understanding, Observation

Analyzing Human Motion

Group Activity

Activity Instructions:

Work in a group. Choose a simple human activity (e.g., walking, jumping, swinging an arm).

1. Design a method to measure aspects of its motion (e.g., measure distance covered and time taken for walking, or estimate the time for a swing).
2. Perform the activity and collect data.
3. Discuss and analyze the data: Is the motion uniform or non-uniform? Can you calculate an average speed? What types of motion are involved?

Questions to Answer:

1. What specific measurements did your group take, and how did you take them?
2. What problems did you face while measuring motion, and how can it be improved?

Skills Covered: Data Collection, Measurement Skills, Analysis, Teamwork, Problem Solving

The School Race Day

Case Study

It's the annual school sports day. During the 100-meter sprint, the athletes run from a starting line to a finish line. The timekeepers use a stopwatch to record each runner's time from the sound of the starting pistol to when their chest crosses the finish line. In the relay race, the runners don't maintain a constant speed throughout their leg; they accelerate at the start and often slow down slightly before passing the baton.

- **Guiding Questions:**
  1. What type of motion does a runner primarily exhibit during the 100-meter sprint from start to finish? Is it uniform or non-uniform?
  2. If a runner completes the 100 meters in 12.5 seconds, how would you calculate their average speed?
  3. In the relay race, why is the motion described as non-uniform?

Skills Covered: Classification, Analysis, Teamwork, Communication, Scientific Investigation

Galileo and the Pendulum

Source Based Question

Source Passage (Historical Account, University of Pisa, 1600s):

It is said that Galileo Galilei, while sitting in a cathedral in Pisa, noticed a lamp swinging back and forth. He observed that no matter how wide or small the swing was, the time it took to complete one swing remained nearly the same. This simple observation led him to study pendulums in detail. Later, pendulums became important for making more accurate clocks. Galileo's discovery showed how careful observation of motion, combined with measuring time, could lead to great scientific advances. Today, pendulums are still used in clocks, experiments, and even in measuring the strength of earthquakes.

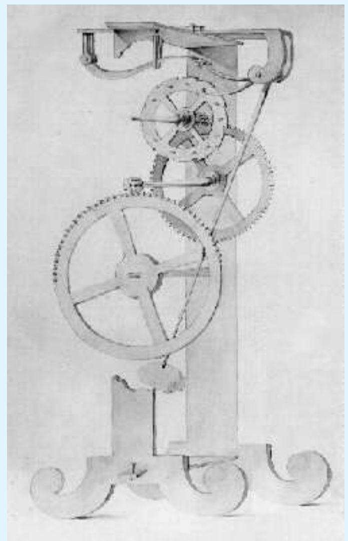


Image Credit : Wikkipedia

Original drawing from around 1637 of the pendulum clock designed by Galileo, incorporating the escapement.

Guiding Questions for Analysis

1. **Understanding Observation and Discovery**
   a) What did Galileo notice about the swinging lamp in Pisa?
   b) How did his observation help in developing more accurate clocks?
2. **Cause and Consequence**
   a) Why is the pendulum considered important in the history of time measurement?
   b) How did Galileo's observation link time and motion together?
3. **Critical Thinking**
   a) Think of a time when you observed something simple in daily life (like a ball bouncing or a swing in a park). How could such an observation lead to scientific learning?
   b) Why do you think pendulums are still useful in science even today?

Skills Covered: Observation, Questioning, Experimenting, Creating, Evaluating