Unit 1

PHYSICAL WORLD

Introduction

Physicists ask the fundamental questions how the universe began. How and of what is it made? How does it change? What rules govern its behaviour?

This chapter discusses what is Science? What is Physics? Fundamental Forces in nature, Famous laws and Discoveries in Physics.

Values and Attitudes

• Increase student enjoyment and interest in science
• Foster positive scientific attitudes and habits of mind
• Help students learn to think independently
• Make science relevant to the students’ everyday lives
## Unit Frame

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<td>➢ Scientific method</td>
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</table>

| ➢ Scope and Excitement of Physics, Technology and Society | • Seminar on branches of physics, scientist and their contribution to technology and society | • Lists different branches of Physics |
| • Observing |                                    |
| • Classifying |                                    |
| • Measuring and charting |                                    |
| • Experimenting |                                    |
| • Using number relationships |                                    |

| ➢ Fundamental forces in nature | • General discussion on Fundamental forces in nature | • Explains and compares fundamental forces in nature |
| Nature of physical laws |                                    |
| • Observing |                                    |
| • Classifying |                                    |

### Assessments

➢ Involvement in group discussion and general discussion (process)
➢ Activity log book (portfolio)
Towards the unit

Content:
- Science, Scientific methods, Physics

Suggested Activity 1.1: General Discussion, ICT video

Teacher shows a video/picture of lightning and asks students to share their experiences of lightning and thunderstorm.

Discussion points:
- Why peoples afraid of lightning/thunderstorm?
- How do thunderstorm and lightning occur?
- Teacher narrates the history of studies on lightning by giving special emphasis on experiments done by Benjamin Franklin.
- Can you explain the real cause of lightning?
  [Hint: Flow of large amount of electric charge between clouds or cloud to earth]
- What were the steps followed by Benjamin Franklin?

Teacher connects the experiments done by the Benjamin Franklin with the steps of scientific method
- What is science?
  [Hints: Teacher defines science]
- How did Benjamin Franklin arrive at a correct explanation for the phenomena of lightening?
  [Hint: From experiment to theory, this is one of the ways of acquiring knowledge in science]
- Most of you will have mobile phone at your home. Which type of wave is used for mobile phone communication?
  [Hint: EM wave]
- Who developed the theory of EM wave?
  [Hint: Maxwell]
- Has he produced EM wave experimentally?
[Hint: No, EM waves are produced experimentally after the death of Maxwell]

Here, theory to experiment. This is another way of acquiring knowledge in science.

- By suitable example teacher explains unification and reduction approach in science
- Teacher helps students to define physics

**Consolidation**

Teacher consolidates the ideas of scientific methods, science as well as physics

**Content:**

Scope and Excitement of Physics, Physics - Technology and Society

**Suggested Activity 1.2: Seminar on branches of physics, scientist and their contribution to technology and society**

Discussion Points:

- Teacher divides the students into different groups and directs each group to prepare and present a seminar.
- **Seminar Topic:** Mechanics, Heat and thermodynamics, Electricity, Magnetism, Optics, Modern physics, Electronics and communication, etc.
- **Points to be discussed:** Topics under the branch of physics, Major contributors (scientists), Applications to technology and society, etc.
- With the help of teacher, students collect data from various sources about the topics.
- Different groups present the seminar before the others with the use of visuals, charts and presentations.
- Other students are allowed to interact with the team for better understanding of the topics presented.

**Content:**

- Fundamental forces in nature
- Nature of physical laws

**Suggested Activity 1.3: General discussion**

Teacher drops a stone and asks the students to observe it.
**Discussion points:**

- Which force is responsible for this motion?
  
  [Hint: Gravitational force]

- Which are the other forces you are familiar with?

- Teacher classifies these forces into basic forces and derived forces and emphasises the significance of basic forces and compares them.

- Teacher leads a discussion on the conservation laws of nature and its connection with the symmetry of nature

**Consolidation**

Teacher consolidates the idea about fundamental forces and conservation laws of nature.

**Repository of CE Items**

1. **Process Assessment**
   
   - General discussion
   
   - Seminar on Scope and excitement of physics and physics, technology and society

2. **Portfolio Assessment**
   
   - Log book – definitions,
   
   - Unit based Assessment

3. **Unit based assessment - Unit test**

4. **ICT possibilities**
   
   - Video showing lightening
   
   - PPT about scientist during seminar

**Reference:**

- NCERT Textbook
- University Physics
- Pradeeps Physics
Unit 02
UNITS & MEASUREMENTS

Introduction
Whatever the science we are going to study, we need to take measurements, express the results in the right format and conscious about the possible errors in calculations.

Physics is inherently a science of measurement. This chapter is regarded as a perfect tool in the study of forthcoming chapters in Physics (other science subjects as well). This chapter helps the students to develop scientific thinking, Problem solving and experimental skills etc.

Values and attitudes
• Minimizing errors and honest in measurements
• Expressing a measurement in proper way
• Developing a feeling of universal integrity
• Comparing with the largest and smallest things, develops a thinking about our position in the universe
• Values Time and develops time management.
## Unit Frame

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<td>General discussion about different physical quantities and their units, fundamental and derived units.</td>
<td>Defines, classifies fundamental and derived units</td>
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<td>List the different units and their symbols used in SI</td>
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<td>Measurement of length</td>
<td>General discussion on parallax method, range of length, mass and time</td>
<td>Performs experiments to find large distance as well as the molecular size</td>
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<tr>
<td>Measurement of Mass</td>
<td>ICT- video showing very small and very large distances</td>
<td>Recognizes the range of length, mass and time</td>
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<td>Measurement of Time</td>
<td>Pin hole experiment to find the diameter of the sun</td>
<td>Explains light year, AU and parsec</td>
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<tr>
<td>• observing</td>
<td>Simple experiment to find the size of molecule</td>
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<tr>
<td>• measuring and charting</td>
<td>ICT- video showing caesium clock</td>
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<td>• experimenting</td>
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<td>Accuracy, precision, error and least count</td>
<td>General discussion on accuracy, precision and least count</td>
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<td>Experiment with vernier calipers and screw gauge</td>
<td>Performs experiments of vernier calipers and screw gauge</td>
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<td>• experimenting</td>
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<tr>
<td>Types of errors and error analysis</td>
<td>General discussion on different types of errors and error analysis</td>
<td>Classifies different types of errors and solves problems related with errors in measurements</td>
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<td>Combination of errors</td>
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</table>
| **Assessments**         | • Involvement in General discussion and experiment (process)  
                           • activity log book (portfolio) | • Identifies the number of significant figures of a number  
                           • Solves problems related with significant figures and rounding off in arithmetic operations |
| Significant figures and order of magnitudes  
Rules for arithmetic operations with significant figures  
Rounding off the uncertain digits  
• Observing  
• Identifying  
• Using number relationship | • General discussion on significant figures, rounding off | |
| Dimensions of physical quantities  
Dimensional analysis and its applications  
• observing  
• Identifying  
• Using number relationships  
• Inferring | • General discussion on dimensions of physical quantities and applications of dimensional analysis | • Selects appropriate dimensions of different physical quantities  
• Uses principle of homogeneity to check the correctness of equations and to deduce the relation among the physical quantities |
Towards the unit

Content 1:
- Physical Quantity and its Units
- Fundamental and Derived Units

Suggested Activity:

2.1.1 General Discussion
Teacher introduces the idea about Physical quantity and Units by asking simple questions
- What is your height?
- What is your mass?
- How old are you?

[Hints: Teacher writes the answers on board as
h = 172 cm
m = 38 kg age = 17 years]

- What are h, m and age?

[Hint: Physical quantities]
- What are cm, kg and years?

[Hint: Units]
Teacher explains that physical quantity is represented as
Physical Quantity = A Number x Unit

Suggested Activity:

2.1.2 Group Discussion
Teacher divides the students into groups and asks them to write different units of Length, Mass and Time.

[Hints:
Length → mm, cm, m, km, mile, foot etc.
Mass → g, kg, tonne, quintal, pound etc.
Time: second, minute, hour, day, week, month, year, etc.]

Teacher says that different systems of units are used all over the world.

With the help of the following chart, teacher introduces some systems of units - CGS, FPS, MKS
Teacher makes the students to realize the relevance of an internationally acceptable system of units.

SI system is introduced using the table 2.1 of NCERT text.

**Suggested Activity:**

2.2.2 General Discussion, ICT - video showing solid angle

Teacher introduces the concepts plane angle and solid angle.

[Hint: Teacher may use the video showing solid angle or by making a cone with a paper piece]

Teacher helps the students to define plane angle and Solid angle \(d\theta = \frac{da}{r}, \quad d\Omega = \frac{dA}{r^2}\).

SI Units of plane and solid angles are mentioned.

**Consolidation**

- Different systems of units
- Plane angle, solid angle and their units

**Worksheet: Appendix 1.1**

**Assessment**

1. Refer Table of SI prefixes for multiples and sub multiples of 10 in Appendix 2 of NCERT Text and answer the following.
   A) \( h = 172 \text{cm}, \text{then} \ h = \ldots \ldots \ldots \text{m} \)
   B) \( ? = 0.000000589 \text{m}, \text{then} \ \lambda = \ldots \ldots \ldots \text{m} \)
   C) \( c = 300000000 \text{m/s}, \text{then} \ c = \ldots \ldots \text{ms}^{-1} \)
   D) 
   E) 

2. \( 10^0 = \ldots \ldots \text{rad}, \quad 1' = \ldots \ldots \text{rad}, \quad 1'' = \ldots \ldots \text{rad} \)
Content 3:

Measurement of Length
- Measurement of Large distance
- Estimation of very small distance: size of molecules

Suggested Activity:

2.3.1 General discussion
How do you relate arc, radius and angle?
(Hint: angle = arc/radius)

Teacher introduces the concepts of Parallax, Parallactic angle and basis using Pencil - Eye activity. (Refer 2.3.1 of NCERT Text)

Teacher helps the students to formulate the equation \( \theta = \frac{b}{D} \)

Extended activity:
Calculation of Sun's diameter - Pin hole Experiment.

Calculation of Sun's diameter - Pin hole Experiment.

Make a pin hole on a card board. Allow sunlight directly fall on it. Image of the sun is obtained on a screen distant \( D_1 \) from the pin hole. By measuring diameter of the image \( b_1 \),

We can calculate the diameter of the Sun \( (b_2) \):

Here, the angle subtended by the diameter of the Sun at the pin hole = angle subtended by the diameter of the image at the pin hole

\[
\frac{b_2}{D_2} = \frac{b_1}{D_1}
\]

\[
b_2 = D_2 \cdot \frac{b_1}{D_1}
\]
Suggested Activity: 2.3.2 General discussion

Measurement of molecular size of soap molecule

Take one drop of liquid soap and dilute it by adding 9 drops of water (concentration of solution is equal to 0.1)

Lightly sprinkle some pepper powder on the surface of water in a large vessel and put one drop of diluted soap solution (of 0.1) on the water surface.

The soap molecules spread into a thin, large and roughly circular film of molecular thickness on the water surface.

Measure the diameter of the thin film and find its area.

\[ A = \pi \left( \frac{d}{2} \right)^2 \]

Volume of n drops of solution= nV.
Amount of soap molecule in n drops of solution (nV x 0.1).

Thickness of soap molecule \( t = \frac{nV \times 0.1}{A} \)

Volume of one drop of soap solution= 1 X 0.05 mm³ = 0.05 mm³.
Volume of soap molecules in one drop = 0.05 mm³ x 0.1 = 0.005 mm³

Diameter of circular soap film =6 cm = 60mm

Area of circular film \( \pi \left( \frac{d}{2} \right)^2 = 2826 \text{ mm}^2 \)

Thickness \( t = \frac{0.005}{28264} \text{ mm} \)

= 1.76 x 10⁻⁶mm

= 1.76 x 10⁻⁹ m

Consolidation

Teacher consolidates the ideas of Parallax method and Measurement of molecular size.

Content: Range of Length

Suggested Activity: 2.3.3 ICT - Video showing very small and large distances, Chart/PPT

Using the video clipping (video showing power of 10 available in U tube), teacher leads a discussion on very small and large distances.
On comparison with the size of universe, students recognize their negligible place and role.

Teacher introduces some special length units by showing the following chart

<table>
<thead>
<tr>
<th>No</th>
<th>Special Unit</th>
<th>SI Equivalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 fermi</td>
<td>$10^{-15}$m</td>
</tr>
<tr>
<td>2</td>
<td>1 Å</td>
<td>$10^{-10}$m</td>
</tr>
<tr>
<td>3</td>
<td>1 AU</td>
<td>$1.496 \times 10^{11}$m</td>
</tr>
<tr>
<td>4</td>
<td>1 Light year</td>
<td>$9.46 \times 10^{15}$m</td>
</tr>
<tr>
<td>5</td>
<td>1 parsec</td>
<td>$3.08 \times 10^{16}$m</td>
</tr>
</tbody>
</table>

Teacher helps the students to define Astronomical Unit, Light year and Parallactic second (parsec).

(AU and Light year are common units of length.

Parsec can be made clear with the help of the following diagram.

**Consolidation**

Teacher consolidates the uses of different units of large distances and their inter relationships.

**Content : Measurement of Mass**

**Suggested Activity : 2.4 General discussion, PPT**

Do you know the mass of electron?

[Hint: Extremely Small]

What about the mass of our universe?

[Hint: Extremely Large]

Teacher shows the chart showing table 2.4 of NCERT Text.

How can we measure these masses?

[Hint: No direct methods. Spectroscopic methods are used]

Is it convenient to express the masses of electrons, atoms or molecules in kg?

[Hint: No]
Teacher brushes up the idea of amu (atomic mass unit) and helps them to define it.

**Consolidation**
Teacher consolidates different ranges of large and small masses

**Assessment**
1. 1 amu = ............ kg
2. Mass of one C-12 atom = ........... amu

**Content : Measurement of Time**

**Suggested Activity**
2.5 : General discussion, Video showing Range of Time & Ceasium clock.
How did the ancient men measure time?
[Hint: By noticing cyclic processes like day - night, seasons, lunar cycles etc.]
What is the SI unit of time?
[Hint: second]

**Consolidation**
Teacher consolidates different ranges of time.

**Assessment**
How many times did your heart beat till now?
(72 beats in a minute)

**Content :**

**Accuracy, Precision and Errors**

**Suggested Activity:**
2.6.1 : General discussion
Teacher asks the students to measure the thickness of their desk.
What are the measured values you got?
(Hint: Probably, the values are different)
Teacher introduces the concept 'Error'. To introduce the concept of Accuracy and precision, teacher writes the following on BB.
If True value = 3.5 cm and
Measured values = 3.4cm, 3.75cm.
Which is more accurate?
[Hint: 3.4cm]
Which is more precise?
[Hint: 3.75cm]
What do you mean by accuracy and precision?
[Hint: Accuracy 'How close the measured value to the true value
Precision 'Limit/Resolution the quantity is measured]
Teacher introduces the concept Least Count (LC).
What is the smallest measurement that can be taken by your metre scale?
[Hint: 1mm]
Teacher makes familiarise Vernier Calipers and Screw gauge. Methods to find Least Count of Vernier and screw gauge are explained.
What is the LC of Vernier Calipers?
[Hint: 0.1mm (0.01cm)]
What is the LC of Screw gauge?
[Hint: 0.01mm (0.001cm)]
Students are divided in to different groups. Metre scale, Vernier Calipers, Screw Gauge are given to each group along with a small rectangular body. They are asked to measure the breadth/thickness.
Measurements are taken. Results are compared.
Why do the results differ?
[Hint: Each has different LCs]
Which is more precise?
[Hint: Measurement using Screw Gauge]

Consolidation:
Teacher consolidates accuracy and precision and errors

Assessment:
A small Lead shot (metallic sphere) is given. Find out its diameter using appropriate instrument?
Content: Types of Errors and error analysis
Suggested Activity 2.6.2: General Discussion, Problem Solving

Teacher starts the discussion by asking the students to list all the possible errors in taking a measurement.

With the help of the chart given below, teacher consolidates the discussion.

<table>
<thead>
<tr>
<th>Type of Error</th>
<th>Causes</th>
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<tr>
<td>Systematic Errors</td>
<td>Instrumental Errors</td>
</tr>
<tr>
<td></td>
<td>Imperfection in Experimental technique/procedure</td>
</tr>
<tr>
<td></td>
<td>Personal Errors</td>
</tr>
<tr>
<td>Random Errors</td>
<td>Arise due to random and unpredictable fluctuations in Experimental conditions</td>
</tr>
<tr>
<td>Least Count Error</td>
<td>Error Associated with the resolution of the instrument</td>
</tr>
</tbody>
</table>

Teacher introduces the concepts of absolute errors, relative error and percentage error by solving the following problem.

[The diameter of a sphere is measured using a screw gauge. The measured values are 2.54cm, 2.53cm, 2.56cm, 2.55cm and 2.57cm.

Measured values:

\[ a_1 = 2.54\text{cm}, a_2 = 2.53\text{cm}, a_3 = 2.56\text{cm}, a_4 = 2.55\text{cm}, a_5 = 2.57\text{cm} \]

How can you find the true value?

[Hint: by taking the Mean value]

\[ a_{\text{mean}} = \frac{a_1 + a_2 + a_3 + a_4 + a_5}{5} = \frac{12.75}{5} = 2.55\text{cm} \]

What are the errors in each measurement?

[They are called Absolute Errors]

\[ \Delta a_1 = |a_1 - a_{\text{mean}}| = |2.54 - 2.55| = 0.01\text{cm} \]
\[ \Delta a_2 = |a_2 - a_{\text{mean}}| = |2.53 - 2.55| = 0.02\text{cm} \]
\[ \Delta a_3 = |a_3 - a_{\text{mean}}| = |2.56 - 2.55| = 0.01\text{cm} \]
\[ \Delta a_4 = |a_4 - a_{\text{mean}}| = |2.55 - 2.55| = 0.00\text{cm} \]
\[ \Delta a_5 = |a_5 - a_{\text{mean}}| = |2.57 - 2.55| = 0.02\text{cm} \]

Students are asked to write the mean of these absolute errors.
\[
\Delta a_{\text{mean}} = \frac{\Delta a_1 + \Delta a_2 + \Delta a_3 + \ldots + \Delta a_n}{n}
\]

\[
\Delta a_{\text{mean}} = \frac{0.06}{5} = 0.012 \text{cm}
\]

How do you relate this with the true value?

Relative Error \(= \frac{\Delta a_{\text{mean}}}{a_{\text{mean}}}
\]

\[
= \frac{0.012}{2.55}
\]

How do you find the percentage error?

\[
\delta = \frac{\Delta a_{\text{mean}}}{a_{\text{mean}}} \times 100\%
\]

\[
\delta = 0.0047 \times 100\% = 0.47\%
\]

**Consolidation:**

Teacher consolidates different types of errors and their calculations.

Content: **Combination of Errors**

Suggested Activity 2.6.3: **General discussion, Problem solving**

1. **Error of a Sum or a difference**

Two lengths are measured as \(A = (5.24 \pm 0.02)\text{cm}\) and \(B = (3.15 \pm 0.01)\text{cm}\), what will be the error in \(A + B\) and \(A - B\)?

- If \(Z = A + B\)

Let errors in \(A\), \(B\) and \(Z\) are \(\Delta A\), \(\Delta B\) and \(\Delta Z\) respectively.

- \(Z \pm \Delta Z = (A \pm \Delta A) + (B \pm \Delta B)\)

  Then \(\pm \Delta Z = \pm \Delta A \pm \Delta B\)

The maximum possible error

\[
\Delta Z = \Delta A + \Delta B
\]

\[
\Delta Z = 0.02 + 0.01 = 0.03
\]

- If \(Z = A - B\)

\[
Z \pm \Delta Z = (A \pm \Delta A) - (B \pm \Delta B)
\]
Then $\Delta Z = \pm \Delta A \pm \Delta B$

The maximum possible error

$(\Delta Z = \Delta A + \Delta B)$

Teacher concluded that when two quantities are added or subtracted, the absolute error in the final result is the sum of absolute errors in the individual quantities.

2. Error of a product or a quotient

If $Z = AB$

$Z \pm \Delta Z = (A \pm \Delta A)(B \pm \Delta B)$

$Z \pm \Delta Z = AB \pm B\Delta A \pm A\Delta B + \Delta A \Delta B$

Dividing LHS by $Z$ and RHS by $AB$

$1 \pm \Delta Z/Z = 1 \pm \Delta A/A \pm \Delta B/B + \Delta A \Delta B$

$\pm \Delta Z/Z = \pm \Delta A/A \pm \Delta B/B$

The maximum possible error is

$\Delta Z/Z = \Delta A/A + \Delta B/B$

$\Delta Z/Z = 0.02/5.24 + 0.01/3.15$

$= 0.00381 + 0.00317 = 0.00698$

If $Z = A/B$

$ZB = A$

$(Z \pm \Delta Z)(B \pm \Delta B) = A \pm \Delta A$

Also we get,

$\pm \Delta Z/Z = \pm \Delta A/A \pm \Delta B/B$

The maximum possible error is

$\Delta Z/Z = \Delta A/A + \Delta B/B$

$\Delta Z/Z = 0.02/5.24 + 0.01/3.15$

$= 0.00381 + 0.00317 = 0.00698$
Teacher concluded that when two quantities are multiplied or divided, the relative error in the final result is the sum of relative errors in the individual quantities.

3. Error in the case of a quantity raised to a power

If the side of a square \( A = (2 \pm 0.02) \text{ cm} \), then what will be the relative error in finding its area?

[Hint: Area of the square

\[ Z = A^2 = AA \]

Using the above result

\[ \Delta Z/Z = \Delta A/A + \Delta A/A \]

\[ \Delta Z/Z = 2 (\Delta A/A) \]

\[ \Delta Z/Z = 2 (0.02/2) = 0.02 \]

Then what will be the relative error in

\[ Z = \frac{A^p + B^q}{C^r} \]

\[ \Delta Z/Z = p(\Delta A/A) + q(\Delta B/B) + r(\Delta C/C) \]

Teacher concluded that the relative error in a physical quantity raised to the power \( k \) is the \( k \) times the relative error in the individual quantity.

**Consolidation:**
Teacher consolidates the combination of errors

**Assessment:**
Assignment: Measure the length and breadth of each room in your home. Repeat the measurements at least 4 times. Find the area of each room and then calculate the total area of your home. Also calculate the absolute errors in each measurement, relative errors and the errors in area

**Content: Significant Figures**

**Suggested Activity 2.7.1: General discussion**
Teacher asks the students to take a measurement. (Ex: diameter of a small sphere using vernier calipers)

[Hint; Say, \( t = 1.25 \text{ cm} \)]
Are you sure about the value?

[Hint: It may be 1.24 or 1.26 etc]

Which are the certain digits?

[Hint: 1 and 2]

Teacher explains that the certain digits + the first uncertain digit in a measurement is called significant figures.

Different rules for determining the number of significant figures are explained with suitable examples.

How many significant figures are there in

A] 123 m
B] 12300 cm
C] 123000 mm

[Hint: Students may erroneously conclude that above three have different significant figures]

Teacher explains that choice of system of units will not affect the number of significant figures.

Also such ambiguities can be removed by expressing it in scientific notation.

\[a \times 10^b\]

If \(a \leq 5\), \(a\) is rounded to 1
If \(5 < a \leq 10\), \(a\) is rounded to 10

The exponent \(b\) is called order of magnitude.

123000 mm can be expressed as \(1.23 \times 10^5\), number of SF is 3.

(Power of 10 is not considered in SF)

What is the order of magnitude of 123000

[Hint: \(1.23 \times 10^5\), Order is 5]

**Consolidation:**

Teacher consolidates the rules for determining significant figures

**Assessment**

1. Length of a body measured by three instruments gives following values. Identify the instrument used for this measurement and note significant figure in each case
Instruments (meter scale with L.C=0.1 cm, vernier calipers, screw gauge)

<table>
<thead>
<tr>
<th>Value</th>
<th>Instrument</th>
<th>Significant figure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.123</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Which instrument gives more precise value?

2. State the number of significant figures in the following:
   (a) 0.007 m²
   (b) 2.64 \times 10^{-4} kg
   (c) 0.2370 g cm⁻³
   (d) 6.320 J
   (e) 6.032 N m²
   (f) 0.0006032 m²

3. Write order of magnitude.

<table>
<thead>
<tr>
<th>Number</th>
<th>a \times 10^b</th>
<th>Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>2.0 \times 10^1</td>
<td>1</td>
</tr>
<tr>
<td>60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>150</td>
<td></td>
<td></td>
</tr>
<tr>
<td>450</td>
<td></td>
<td></td>
</tr>
<tr>
<td>600</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4800</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>52000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.0002</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Content: Rules for arithmetic operations with significant figures

Suggested Activity 2.7.2 General discussion, problem solving

Teacher explains the rules governing significant figures in arithmetic operations using the following examples.
1. Addition/Subtraction
Write the result in correct significant figures.
   A) 436.32g + 227.2g
   B) 0.307m - 0.304m
Teacher mentions the rule for addition and Subtraction.
In addition or subtraction, the final result should retain as many decimal places as are there in the number with the least decimal places.
So, the answer will be,
A) 663.5 (and not 663.52)
B) 0.003m (3 \times 10^{-3})

2. Multiplication/Division
Write the result in correct significant figures
A) Area = 2.54m \times 3.6m
B) Density = 4.327g / 2.51 \text{ cm}^3
Teacher mentions the rule for Multiplication and Division.
In multiplication or division, the final result should retain as many significant figures as are there in the original number with the least significant figures.
So, the answers will be,
A) 9.1 (and not 9.144)
B) 1.72 (and not 1.7239043 \ldots)

Consolidation:
Teacher consolidates the rules for significant figures in a calculation.

Worksheet: Appendix 1.2

Assessment
Express the result in proper significant figures.
3.05 - 10.02 \times (5.3 + 2) \div 3.07
(Ans: 20)
Content: Rounding off the uncertain digit

Suggested Activity 2.7.3: General discussion
You might be familiar with the term rounding off.
While you make a purchase, it is usual practice to bargain and ask them to round off.
But there are some simple rules for the process of rounding.
With the use of examples teacher explains the rules for rounding off the uncertain digits.

Consolidation:
Teacher consolidates the rules for rounding off.
Worksheet: Appendix 2.3
Content: Dimensions of Physical quantities
Suggested Activity 2.8: General discussion
What is the expression for force?
[Hint: F = ma]
What are the physical quantities involved in Force?
[Hint: Mass and acceleration]
How can you express Force in terms of base quantities?
F = mass \times acceleration
F = mass \times length/time^2
Like this, all the physical quantities can be represented as the combination of base quantities.
Therefore, these base quantities are the dimensions of the physical world.
Teacher introduces the definition of dimension of a physical quantity.
[The power (or exponent) to which the base quantities are raised to represent that quantity]

Content: Dimensional formula and dimensional equation

Suggested Activity 2.9: General discussion
Teacher explains that dimensions of base quantities can be represented as
Mass → [M]  
Length → [L]  
Time → [T]  
Temperature → [K]  
Electric Current → [A]  
Amount of Substance → [mol]  
Luminous Intensity → [cd]  

Then the dimension of a physical quantity is represented as the symbols of base quantities (M, L T etc.) given above in square brackets.

How can you represent the dimension of force?  
(mass → power = 1, length → power = 1, time → power = 2)  
(MLT⁻²)

(This is dimensional formula of force)  
Write the dimensional equation of force?  
(Hint : [F] = [MLT⁻²])

**Consolidation:**

Any physical quantity can be represented in terms of base quantities. Dimensional formula and dimensional equation are differentiated.

**Assessment**

What are the dimensions of mass, length and time in Pressure?

Worksheet: Appendix 2.4

**Content**

Dimensional Analysis and its Applications (Checking the dimensional consistency of an equation)

**Suggested Activity 2.10.1 : General discussion**

Teacher introduces the principle of homogeneity. Using this teacher helps the students to check an equation dimensionally correct or not.

(Eg: v = u + at)
How many terms are there in this equation? (3, terms are separated by -, + and -)

What are the dimensions of the terms?

\[ [v] = [LT^{-1}] \]
\[ [u] = [LT^{-1}] \]
\[ [at] = [a] \times [t] = [LT^{-2} \cdot T] = [LT^{-1}] \]

The dimensions of all terms are the same.

**Assessment**

Check the dimensional consistency of the following equations

1. \( x = x_0 + ut + \frac{1}{2} at^2 \)
2. \( v^2 = u^2 + 2as \)
3. What is the dimension of \( x \) in the equation \( v = \sqrt{2gh} \)
4. Find the dimensional formula of \( G \) in the equation \( F = \frac{Gm_1m_2}{r^2} \)

**Content: Dimensional Analysis and its Applications (Deducing relation among the physical quantities)**

**Suggested Activity 2.10.2: General discussion, Problem solving**

Teacher introduces a new idea that dimensional method can be employed for deducing relation among physical quantities.

Teacher helps the students to find an equation for time period of a simple pendulum using this method.

What are the physical quantities depend on time period of a simple pendulum?

[Teacher eliminates the dependent variables and selects the linearly independent variables \( m, l \) and \( g \)]

Teacher expresses the relation as

\( T \propto m^xg^y \rightarrow (1) \)

Why do we use the powers as \( x, y \) and \( z \)?

[we are not sure about the dimensions of the physical quantities]

The proportionality can be eliminated by providing a dimensionless constant.
\[ T = K \cdot m^0 \cdot l^y \cdot g^z \]

Replacing the equation using dimensions

\[ [T] = [m]^1[l]^y[g]^z \]

\[ [M^0 L^y T^z] = [M]^1[L]^y[T]^z \]

Equating the dimensions on both sides

\[ x = 0, \quad y = \frac{1}{2}, \quad z = - \frac{1}{2} \]

Equation (1) becomes,

\[ T = K m^0 l^{1/2} g^{-1/2} \]

\[ T = K \sqrt{\frac{l}{g}} \]

Put \( K = 2\pi \) (\( K \) is already calculated in experiment as \( 2\pi \))

\[ T = 2\pi \sqrt{\frac{l}{g}} \]

Teacher mentions the limitations of dimensional method

**Consolidation:**

Teacher consolidates the principle of homogeneity and its applications

**Assessment:**

Centripetal force of a body depends on its mass, velocity and radius of the path. Deduce an expression for centripetal force. (Take \( k = 1 \))
REPOSITORY OF CE ITEMS

1. Process Assessment
   - General discussion
   - Group discussion
   - Assignment on measuring area of your home

2. Portfolio Assessment
   - Log book - definitions, units and dimensions of different physical quantities, solutions of problems related with conversion of units, error analysis and dimensional analysis
   - Figure to measure large distances

3. Unit based Assessment
   - Conduct a unit test

4. Open book Examination
   - The average distance of the moon from the earth is $3.8 \times 10^8$ m and the radius of the earth is $6.4 \times 10^6$ m. What is the angle subtended at the moon by the two diametrically opposite points on the earth? (Ans: $1^\circ 55'$)
   - A certain physical quantity $M$ is given by the relation:
     \[
     M = \frac{ab^2c^\frac{1}{2}}{e^3}
     \]
     The percentage error of measurement in $a$, $b$, $c$, $d$, and $e$ are 0.5%, 2%, 1.2%, 0.5%, and 2% respectively. What is the total percentage error in measurement of $M$? (Ans: 8.4%).
   - The wavelength $\lambda$ associated with a moving electron depends upon its mass $m$, velocity $v$, and Planck's constant $h$. For a dimensionless constant $k$, the dependence of $\lambda$ on $m$, $v$, and $h$ is written as
     
     \[
     \begin{align*}
     A: \quad & \lambda = kmvh \\
     B: \quad & \lambda = kmvh^2 \\
     C: \quad & \lambda = k \frac{hv}{m} \\
     D: \quad & k \frac{h}{m}
     \end{align*}
     \]
     (Ans: D)
• The dimension of power is given as $M^1 L^3 T^{-2}$. What are the respective values of $a$, $b$, and $c$? (Ans: 1, 2, -3)

5. ICT possibilities
   • Video showing small to large sizes
   • PPT showing charts of ranges of length, mass and time
   • video showing the working of Caesium clock

SAMPLE TE ITEMS

1. A) Which of the following numbers has the maximum significant figures?
   
   i) 0.02456 kg
   ii) 0.07630 kg
   iii) $6.141 \times 10^{-24}$ kg
   iv) $7.0140 \times 10^{11}$ kg

   B) Give a physical quantity with a unit and no dimension

   C) Arrange the following in the descending order

   1 light year, 1 Par sec, 1 Astronomical unit.

   (Score: 1+1+1 = 3)

2. A) The initial temperature of an iron rod is $84.2 \pm 0.6$ °C. It is cooled to a temperature of $60.8 \pm 0.8$ °C. What is the fall in temperature of the iron rod?
   
   i) $23.4 \pm 0.2$ °C
   ii) $23.4 \pm 1.4$ °C
   iii) $23.4 \pm (0.02)$ °C
   iv) $23.4 \pm (0.14)$ °C

   B) Group the given quantities in to suitable pairs according to their dimensions, write the dimension of each pair

   (Force, Energy, Angle, Strain, Stress, Pressure, Weight, Torque)

   C) Check the dimensional correctness of the equation $v^2 = u^2 + 2aS$

   (Score: 1+1.5+1.5 = 4)

3. Match the following

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Force</td>
<td>$[M^0 L^1 T^{-2}]$</td>
</tr>
<tr>
<td>Momentum</td>
<td>$[M^1 L^1 T^{-2}]$</td>
</tr>
<tr>
<td>Angular speed</td>
<td>$[M^1 L^{-1} T^{-1}]$</td>
</tr>
<tr>
<td>Pressure</td>
<td>$[M^1 L^{-1} T^{-2}]$</td>
</tr>
</tbody>
</table>

   (Score: $\frac{1}{2} \times 4 = 2$)
4. The readings taken by a student in measuring diameter of a sphere using a vernier calliper is given below

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>MSR (cm)</th>
<th>VSR (div)</th>
<th>Total (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.2</td>
<td>3</td>
<td>1.23</td>
</tr>
<tr>
<td>2</td>
<td>1.2</td>
<td>2</td>
<td>1.22</td>
</tr>
<tr>
<td>3</td>
<td>1.2</td>
<td>1</td>
<td>1.21</td>
</tr>
<tr>
<td>4</td>
<td>1.2</td>
<td>2</td>
<td>1.22</td>
</tr>
<tr>
<td>5</td>
<td>1.2</td>
<td>5</td>
<td>1.25</td>
</tr>
</tbody>
</table>

A) Find the mean diameter of the sphere

B) What are the absolute errors in the measurements?

C) Find the Percentage error in the measurement. (Score: 1+1.5+1.5 = 4)

5. An equation connecting different physical quantities is given below:

\[ X = (Y + Z) PQ + KPQ \] where X denotes Force.

A) What is the dimension of X?

B) Find the dimension of K if the dimension of Y is M^t L^2 T^0

C) In the above equation, the dimension of Q is M^t L^2 T^{-2}. Can you suggest a physical quantity which denotes P? (Score: 1+1.5+1.5 = 4)

6. Time period of a simple pendulum depends on length of the pendulum and acceleration due to gravity at the place.

A) What is principle of homogeneity?

B) Deduce an expression for time period of a simple pendulum using dimensional analysis (Take constant as 2\pi). (Score: 2+1= 3)

SAMPLE PE ITEMS

1. Measure diameter of a sphere using vernier calipers and hence calculate its volume

2. Measure diameter of a metal wire using screw gauge and find its volume

3. Measure thickness of glass plate using spherometer and find its area. Mass and density of glass plate are given.
REFERENCES

- NCERT Physics Class 11 - Part 1
- Fundamentals of Physics: Haliday, Resnick and Walker
- Video showing small to large sizes (www.scaleofuniverse.com)
- Video showing the working of cesium clock(http://www.youtube.com/watch?v=jFyAQkIOkio)
- measurement of molecular size(www.sciencelearn.org.nz)
- University Physics: Hugh D. Young and Roger A. Freedman
- Concepts of Physics: HC Verma

WORKSHEETS

Chapter 2 | Appendix 1.1

3. Complete the table

<table>
<thead>
<tr>
<th>No.</th>
<th>Derived Qty</th>
<th>Relation with Fundamental Qty</th>
<th>SI Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Area</td>
<td>lb</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Volume</td>
<td>lb/t</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Density</td>
<td>m/V</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Velocity</td>
<td>Δx/Δt</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Acceleration</td>
<td>v/t</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Momentum</td>
<td>mv</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Force</td>
<td>ma</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Work</td>
<td>Fd</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>KE</td>
<td>½ mv²</td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>PE</td>
<td>mgh</td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>Power</td>
<td>W/t</td>
<td></td>
</tr>
</tbody>
</table>
Chapter 2 | Appendix 2.2

1. Dimensions of a rectangular block measured by a vernier calipers are shown below:

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Value</th>
<th>Significant figure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>1.11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.10</td>
<td>(4.3 or 4.30)</td>
</tr>
<tr>
<td></td>
<td>1.09</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.00</td>
<td>(1.075 or 1.08)</td>
</tr>
<tr>
<td>Sum Average</td>
<td>..................</td>
<td>(1.35 or 1.3)</td>
</tr>
<tr>
<td></td>
<td>..................</td>
<td>(0.3375 or 0.34)</td>
</tr>
<tr>
<td>Breadth</td>
<td>0.32</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.34</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.35</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.34</td>
<td></td>
</tr>
<tr>
<td>Sum Average</td>
<td>..................</td>
<td>(0.25 or 0.2)</td>
</tr>
<tr>
<td></td>
<td>..................</td>
<td>(0.083 or 0.08)</td>
</tr>
</tbody>
</table>

a. Find area of rectangular block (length x breadth) = .................. (0.36 or 0.37)

b. Find volume of rectangular block = ..................

Chapter 2 | Appendix 2.3

<table>
<thead>
<tr>
<th>NUMBER</th>
<th>Number of decimal places desired</th>
<th>Last figure to be kept</th>
<th>First figure to be dropped</th>
<th>Last figure kept and/or number becomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.422</td>
<td>1</td>
<td>6.4</td>
<td>6.42</td>
<td>6.4</td>
</tr>
<tr>
<td>6.4872</td>
<td>2</td>
<td>6.48</td>
<td>6.487</td>
<td>6.49</td>
</tr>
<tr>
<td>6.997</td>
<td>2</td>
<td>6.99</td>
<td>6.997</td>
<td>7.00</td>
</tr>
<tr>
<td>6.6500</td>
<td>1</td>
<td>6.6</td>
<td>6.65</td>
<td>6.6</td>
</tr>
<tr>
<td>7.485</td>
<td>2</td>
<td>7.48</td>
<td>7.485</td>
<td>7.48</td>
</tr>
<tr>
<td>6.755000</td>
<td>2</td>
<td>6.75</td>
<td>6.755</td>
<td>6.76</td>
</tr>
<tr>
<td>8.995</td>
<td>2</td>
<td>8.99</td>
<td>8.995</td>
<td>9.00</td>
</tr>
</tbody>
</table>
Complete the table.

<table>
<thead>
<tr>
<th>No.</th>
<th>Physical Qty</th>
<th>Relation with Fundamental Qty</th>
<th>Dimensional Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Area</td>
<td>lb</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Volume</td>
<td>lbt</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Density</td>
<td>m/V</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Velocity</td>
<td>(\Delta x/\Delta t)</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Acceleration</td>
<td>(\Delta v/\Delta t)</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Momentum</td>
<td>mv</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Force</td>
<td>ma</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Work</td>
<td>Fd</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>KE</td>
<td>(\frac{1}{2}mv^2)</td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>PE</td>
<td>mgh</td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>Power</td>
<td>W/t</td>
<td></td>
</tr>
</tbody>
</table>