CLASS 9 · PHYSICS · PCTB

Chapter 1: Measurements

Complete Solved Exercise — Sections A to E

✅ MCQs Ticked & Explained

📝 Short & Comprehensive Answers

🔢 Numericals Solved Step-by-Step

Prepared as a complete, easy-to-follow study companion

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Section A — Multiple Choice Questions

Tick (✓) the correct answer — each answer is highlighted in green and explained below it.

Q1 **The instrument that is most suitable for measuring the thickness of a few sheets of cardboard is a:**

(a) metre rule

(b) measuring tape

(c) Vernier Callipers

✓ **(d) micrometer screw gauge**

EXPLANATION

A metre rule (least count 1 mm) and a measuring tape are far too coarse for a thickness of only a fraction of a millimetre. Vernier Callipers are better (least count 0.01 cm) but the micrometer screw gauge has the finest least count of all these instruments, typically 0.01 mm (0.001 cm). Since the thickness of a few sheets of cardboard is very small, the micrometer screw gauge gives the most precise reading.

Q 2 **One femtometre is equal to:**

(a) 10^{-9} m

✓ **(b) 10^{-15} m**

(c) 10^{9} m

(d) 10^{15} m

EXPLANATION

The prefix **femto (f)** always represents the sub-multiple 10^{-15}. Therefore, 1 femtometre (fm) = 10^{-15} m. (Note: 10^{-9} m is a *nanometre*, not a femtometre.)

Q 3 **A light year is a unit of:**

(a) light

(b) time

✓ **(c) distance**

(d) speed

EXPLANATION

A light year is the **distance** travelled by light in vacuum in one year ($\approx 9.46 \times 10^{15}$ m). Although its name contains the word "light" and it is derived using time (one year), the quantity it actually measures is distance — it is commonly used in astronomy to express huge interstellar distances.

Q 4 Which one is a non-physical quantity?

(a) distance

(b) density

✓ **(c) colour**

(d) temperature

EXPLANATION

Distance, density and temperature can all be measured with an instrument and expressed as a number with a unit (m, kg m^{-3}, K). **Colour**, on the other hand, is a qualitative sensory property — it cannot be directly measured with an instrument and given a numerical value in the way physical quantities are, so it is a non-physical quantity.

Q 5 **When using a measuring cylinder, one precaution to take is to:**

(a) check for the zero error

(b) look at the meniscus from below the level of the water surface

(c) take several readings by looking from more than one direction

✓ (d) position the eye in line with the bottom of the meniscus

EXPLANATION

A liquid such as water forms a concave meniscus in a measuring cylinder. To avoid **parallax error**, the eye must be positioned exactly level with — in a straight line with — the bottom of the meniscus (the lowest point of the curve) while taking the reading, not above or below it.

Q 6 **Volume of water consumed by you per day is estimated in:**

(a) millilitre

✓ **(b) litre**

(c) kilogram

(d) cubic metre

EXPLANATION

A person drinks roughly 1–3 litres of water a day. The **litre** is a convenient, everyday-sized unit for this amount — millilitre is too small a unit to state conveniently, kilogram is a unit of mass (not volume), and cubic metre is far too large for daily water intake.

Q 7 **A displacement can is used to measure:**

(a) mass of a liquid

(b) mass of a solid

(c) volume of a liquid

✓ **(d) volume of a solid**

EXPLANATION

A displacement can is filled to the brim with liquid. When an irregular solid is lowered into it, the liquid it displaces (overflow) is collected and its volume is measured. Since the volume of liquid displaced equals the volume of the solid immersed, this method is used to find the **volume of an (irregularly shaped) solid**.

Q 8 **Two rods with lengths 12.321 cm and 10.3 cm are placed side by side, the difference in their lengths is:**

(a) 2.02 cm

✓ **(b) 2.0 cm**

(c) 2 cm

(d) 2.021 cm

EXPLANATION

Direct subtraction gives 12.321 - 10.3 = 2.021 cm. However, in addition/subtraction the answer can only be as precise as the **least precise** measurement used. 10.3 cm is known only to one decimal place, so the final answer must also be rounded to one decimal place: **2.0 cm**.

Q 9 **Four students measure the diameter of a cylinder with Vernier Callipers. Which of the following readings is correct?**

(a) 3.4 cm

(b) 3.475 cm

✓ **(c) 3.47 cm**

(d) 3.5 cm

EXPLANATION

Vernier Callipers have a least count of 0.01 cm, so a correctly recorded reading must be stated to exactly **2 decimal places**. 3.4 cm and 3.5 cm have only 1 decimal place (too few), while 3.475 cm has 3 decimal places (implies a precision the instrument does not have). Only **3.47 cm** matches the instrument's least count.

Q 10 **Which of the following measures are likely to represent the thickness of a sheet of this book?**

(a) 6×10^{-25} m

✓ **(b) 1×10^{-4} m**

(c) 1.2×10^{-15} m

(d) 4×10^{-2} m

EXPLANATION

A single page of a book is roughly 0.1 mm thick. Converting: 0.1 mm = 1×10^{-4} m. The other options are absurd — 10^{-25} m and 10^{-15} m are far smaller than even an atom, while 4×10^{-2} m (4 cm) is far too thick for a single sheet of paper. So **1×10^{-4} m** is the realistic value.

Q 11 **In a Vernier Callipers, ten smallest divisions of the Vernier scale are equal to nine smallest divisions of the main scale. If the smallest division of the main scale is half a millimetre, the Vernier constant is equal to:**

(a) 0.5 mm

(b) 0.1 mm

✓ **(c) 0.05 mm**

(d) 0.001 mm

EXPLANATION

Given: 10 VSD = 9 MSD → 1 VSD = 0.9 MSD.

Vernier Constant (least count) = 1 MSD - 1 VSD = 1 MSD - 0.9 MSD = 0.1 MSD.

Since 1 MSD = 0.5 mm, Vernier Constant = 0.1 × 0.5 mm = **0.05 mm**.

Section B — Short Answer Questions

Concise, complete answers for every short-answer question.

B1 Can a non-physical quantity be measured? If yes, then how?

Non-physical quantities (such as beauty, honesty, intelligence or happiness) cannot be measured directly with a physical instrument because they have no fixed, universally agreed unit. However, they can sometimes be assessed **indirectly** on a comparative or rating scale — for example, intelligence is estimated indirectly through an IQ test, and pain is rated by patients on a scale of 1 to 10. These are subjective estimates rather than true physical measurements.

B2 What is measurement? Name its two parts.

Measurement is the process of **comparing an unknown physical quantity with a recognised standard (a unit)** of the same kind. Every measurement consists of two parts: **(i) a numerical value (magnitude)** and **(ii) a unit**. For example, in "5 metres", 5 is the numerical value and metre is the unit.

B3 Why do we need a standard unit for measurements?

A standard unit is fixed, universally accepted and does not change with time, place or the person measuring. Without it, everyone might use their own reference (a hand-span, a foot, a stride) and the same object would give different results for different people, making measurements meaningless for comparison, trade, science and engineering. A standard unit ensures every measurement is **consistent, reliable and universally understood**.

B4 **Write the name of 3 base quantities and 3 derived quantities.**

Base quantities: length, mass, time (also current, temperature, amount of substance, luminous intensity).
Derived quantities: area, volume, speed (also density, force, acceleration, etc.) — each obtained by combining two or more base quantities.

B5 **Which SI unit will you use to express the height of your desk?**

The **metre (m)** — since the height of a desk is of the order of about a metre, this is the most convenient SI unit (a smaller sub-multiple such as centimetre may also be used in practice, but the SI base unit is the metre).

B6 **Write the name and symbols of all SI base units.**

Base Quantity	Unit Name	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Temperature	kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

B7 **Why prefix is used? Name three sub-multiple and three multiple prefixes with their symbols.**

Prefixes are used to conveniently express **very large or very small** quantities without writing long strings of zeros or a cumbersome power of ten every time.

Sub-multiples: milli (m) = 10^{-3}, micro (μ) = 10^{-6}, nano (n) = 10^{-9}.

Multiples: kilo (k) = 10^{3}, mega (M) = 10^{6}, giga (G) = 10^{9}.

B8 **What is meant by: (a) 5 pm (b) 15 ns (c) 6 μm (d) 5 fs**

(a) 5 pm = 5 picometres = 5×10^{-12} m

(b) 15 ns = 15 nanoseconds = 15×10^{-9} s

(c) 6 μm = 6 micrometres = 6×10^{-6} m

(d) 5 fs = 5 femtoseconds = 5×10^{-15} s

B9 **(a) For what purpose is a Vernier Callipers used? (b) Name its two main parts. (c) How is least count found? (d) What is meant by zero error?**

(a) A Vernier Callipers is used to measure small lengths precisely — external length/diameter, internal diameter, and depth of objects — to a precision of about 0.01 cm.
(b) Its two main parts are the **main scale** (fixed) and the **Vernier scale** (sliding).
(c) Least count = (value of one main scale division) ÷ (total number of divisions on the Vernier scale).
(d) **Zero error** is the (non-zero) reading shown by the instrument when its jaws are fully closed together — it should read exactly zero, but due to wear or a manufacturing defect it may not, so this error must be subtracted from (or added to) every observed reading.

B10 **(a) For what purpose, a Vernier Callipers is used, its two main parts, least count, zero error.**

See the answer to Question 1.9 above — the same explanation of purpose, parts, least count and zero error applies.

B11 **State least count and Vernier scale reading as shown in the figure, and hence find the length.**

From the figure: the main scale is graduated in millimetres (1 MSD = 0.1 cm) and the Vernier scale has 10 divisions numbered 0, 5, 10, so the least count = 1 MSD ÷ 10 = 0.1 mm = **0.01 cm**.
The zero of the Vernier scale lies just before the 3 cm mark, giving a Main Scale Reading (MSR) = **2.80 cm**, and the 5th Vernier division exactly coincides with a main-scale line, so the Vernier Scale Reading (coinciding division) = 5.
Length = MSR + (Vernier division × Least Count) = 2.80 cm + (5 × 0.01 cm) = **2.85 cm**.

B11 **Which reading out of A, B and C shows the correct length and why?**

Reading **B (6.0 cm)** is correct. In the figure, B's line of sight is positioned exactly perpendicular to (directly in line with) the scale, so it is free of parallax error. Readings A (5.9 cm) and C (6.1 cm) are taken by looking at the scale from a slanted angle (from the left and right respectively), which introduces **parallax error** and makes the rod appear shorter or longer than its actual length.

Section C — Constructed Response Questions

Question 1.1 — In what unit will you express each of the following?

C1.1 **Suitable unit for each quantity:**

Quantity	Suitable SI Unit
Thickness of a five-rupee coin	**millimetre (mm)**
Length of a book	**centimetre (cm)**
Length of a football field	**metre (m)**
The distance between two cities	**kilometre (km)**
Mass of a five-rupee coin	**gram (g)**
Mass of your school bag	**kilogram (kg)**
Duration of your class period	**minute (min)**
Volume of petrol filled in the tank of a car	**litre (L)**
Time to boil one litre of milk	**minute (min)**

C2 Why might a standard system of measurement be helpful to a tailor?

A tailor takes many body measurements (chest, waist, sleeve length, etc.) to stitch clothes that fit properly. Using a **standard system of measurement** (like cm or inches) ensures that these measurements mean the same thing to every tailor, shop or customer, so a garment made from recorded measurements will fit correctly no matter who takes or reads them — avoiding confusion and mistakes in cutting and stitching.

C3 The minimum main scale reading of a micrometer screw gauge is 1 mm and there are 100 divisions on the circular scale. When the thimble is rotated once, 1 mm is its measurement on the main scale. What is the least count of the instrument? Find the reading for the thickness of a steel rod as shown in the figure.

Least count = (pitch) ÷ (number of circular scale divisions) = 1 mm ÷ 100 = **0.01 mm**.

Reading from the figure:
Main Scale Reading (MSR) = 9 mm (the last fully visible main-scale mark before the thimble edge)
Circular Scale Reading (CSR) = 70 divisions (the division level with the sleeve's index line)

Thickness = MSR + (CSR × Least Count) = 9 mm + (70 × 0.01 mm) = 9 mm + 0.70 mm = **9.70 mm**.

C4 You are provided a metre scale and a bundle of pencils; how can the diameter of a pencil be measured using the metre scale with the same precision as that of Vernier Callipers? Describe briefly.

A single pencil's diameter (a few millimetres) is too small to read precisely on a metre scale (least count 1 mm). Instead, use the **bundle method**: place a known number of pencils (say, 20) tightly side by side so they touch each other in a straight row, and measure the total width of the bundle with the metre scale. Divide this total width by the number of pencils to get the diameter of a single pencil.

Example: If 20 pencils together measure 140 mm, diameter of one pencil = 140 mm ÷ 20 = 7.00 mm. Spreading the 1 mm reading uncertainty over 20 pencils reduces the error per pencil to about 0.05 mm — comparable to the precision of Vernier Callipers.

C5 **The end of a metre scale is worn out. Where will you place a pencil to find the length?**

Do not start measuring from the damaged zero end. Instead, place one end of the pencil at a clear, undamaged mark further along the scale (e.g., the 1 cm or 2 cm mark) and note the reading at the other end of the pencil. The **length of the pencil = (final reading) - (starting reading)**. Subtracting the readings automatically cancels out the error caused by the worn-out end.

C6 **Why is it better to place the object close to the metre scale?**

Placing the object as close as possible to (or touching) the scale minimises the perpendicular gap between the object and the markings. This reduces **parallax error**, since the line of sight from the eye to the marking passes almost directly over the object's edge, giving a more accurate reading.

C7 Why is a standard unit needed to measure a quantity correctly?

A standard unit is fixed and universally accepted, so a measurement made using it gives the same result regardless of who measures it, where, or when. This allows accurate **communication, comparison and reproducibility** of measurements in everyday life, trade, industry and scientific research.

C8 **Suggest some natural phenomena that could serve as a reasonably accurate time standard.**

- Rotation of the Earth about its own axis — basis of a **day**
- Revolution of the Earth around the Sun — basis of a **year**
- Vibration/oscillation of Caesium-133 atoms — basis of the modern **atomic second**
- Phases of the Moon — basis of a **lunar month**
- Regular swing of a simple pendulum — a periodic natural motion

C9 **It is difficult to locate the meniscus in a wider vessel. Why?**

In a wide vessel, the liquid surface curves only very gently over a large area, so the meniscus is very flat and spread out, making its lowest point hard to pinpoint precisely. In a narrow tube (like a measuring cylinder), the meniscus is sharply and distinctly curved because of stronger surface-tension effects relative to the tube's width, so its lowest point is easy to identify accurately.

C10 **Which instrument can be used to measure: (i) internal diameter of a test tube (ii) depth of a beaker?**

(i) The internal diameter of a test tube is measured using the **upper (internal) jaws** of a Vernier Callipers.
(ii) The depth of a beaker is measured using the **depth-measuring rod/strip** attached to the end of the Vernier Callipers.

Section D — Comprehensive Questions

Detailed, exam-ready explanations for every comprehensive question.

D1 What is meant by base and derived quantities? Give the names and symbols of SI base units.

Base quantities are physical quantities that are independently defined and not derived from any other quantity; they form the foundation of the SI system. **Derived quantities** are physical quantities obtained by mathematically combining (multiplying/dividing) two or more base quantities, e.g. speed = length ÷ time.

Base Quantity	Unit Name	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Temperature	kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

D2 **Give three examples of derived units in SI. How are they derived from base units? Describe briefly.**

1. Area = length × length → unit: square metre (m^2)
2. Speed = distance ÷ time → unit: metre per second ($m\ s^{-1}$)
3. Force = mass × acceleration → unit: $kg \cdot m \cdot s^{-2}$ which is given the special name **newton (N)**

Each derived unit is obtained by combining the relevant base units according to the mathematical definition of that quantity (multiplying or dividing them as the formula requires).

D3 **State the similarities and differences between Vernier Callipers and micrometer screw gauge.**

Similarities: Both are precision instruments used to measure small lengths; both consist of a main/fixed scale together with a second finely divided scale (Vernier / circular) that gives a finer reading; both can develop a zero error that must be accounted for; both are widely used in laboratories and workshops.

Feature	Vernier Callipers	Micrometer Screw Gauge
Least count	0.01 cm (0.1 mm)	0.001 cm (0.01 mm)
Working principle	Sliding jaw with Vernier scale	Screw-and-nut (thimble rotation)
What it measures	Length, internal diameter, depth	Very small thickness / diameter of thin objects and wires

Typical range	Up to ~15–20 cm	0–25 mm per instrument

D4 **Identify and explain the reasons for human errors, random errors and systematic errors in experiments.**

Human error: Arises from the carelessness or mistakes of the observer, e.g. misreading a scale, faulty recording, or miscounting divisions. It can largely be avoided with careful, attentive technique.

Random error: Small, unpredictable fluctuations in readings caused by uncontrollable factors (e.g. slight variation in judging the same reading, air currents, vibration). These scatter readings randomly above and below the true value, and are reduced by taking several readings and calculating the average.

Systematic error: A consistent error, of the same size and direction in every reading, usually caused by a fault in the instrument (such as a zero error) or a flawed procedure. Since it always shifts readings the same way, it cannot be removed by averaging — it must be corrected by calibrating the instrument or applying a correction to every reading.

D5 Differentiate between precision and accuracy of a measurement with examples.

Precision refers to how close repeated measurements of the same quantity are to one another (i.e. their consistency/reproducibility), regardless of whether they are close to the true value.
Example: Measuring the same length five times gives 5.02 cm, 5.01 cm, 5.03 cm, 5.02 cm, 5.02 cm — these values are very close together, so they are **precise**, even if the true length happens to be 5.20 cm.

Accuracy refers to how close a measurement is to the true (actual) value of the quantity.
Example: If the true mass of an object is 50.0 g, and a balance gives 49.9 g, 50.1 g and 50.0 g — these readings are scattered a little (less precise) but are all close to the true value, so they are **accurate**.

An ideal measurement is both precise and accurate.

Section E — Numerical Problems

Every numerical worked out step by step, with the final answer boxed at the end.

Numerical 1. Calculate the number of seconds in a (a) day (b) week (c) month, and state your answers using SI prefixes.

STEP-BY-STEP SOLUTION

(a) One day:

1 day = 24 h × 60 min/h × 60 s/min = 86 400 s = **86.4 ks**

(b) One week:

1 week = 7 days = 7 × 86 400 s = 604 800 s = **604.8 ks**

(c) One month (≈ 30 days):

1 month = 30 × 86 400 s = 2 592 000 s = **2.592 Ms**

Final Answer: 86.4 ks, 604.8 ks, 2.592 Ms

Numerical 2. State the answers of problem 1.1 in scientific notation.

STEP-BY-STEP SOLUTION

Simply rewrite each value from Q1.1 in the form $a \times 10^n$ $(1 \le a < 10)$:

86 400 s = 8.64×10^4 s

604 800 s = 6.048×10^5 s

2 592 000 s = 2.592×10^6 s

Final Answer: 8.64×10^4 s, 6.048×10^5 s, 2.592×10^6 s

Numerical 3. Solve the following addition or subtraction. State your answers in scientific notation.
(a) 4×10^{-4} kg + 3×10^{-5} kg (b) 5.4×10^{-6} m - 3.2×10^{-5} m

STEP-BY-STEP SOLUTION

(a) First make the powers of ten equal:
3×10^{-5} kg = 0.3×10^{-4} kg
4×10^{-4} kg + 0.3×10^{-4} kg = **4.3×10^{-4} kg**

(b) Convert to the same power of ten:
5.4×10^{-6} m = 0.54×10^{-5} m
0.54×10^{-5} m - 3.2×10^{-5} m = **-2.66×10^{-5} m**

Final Answer: (a) 4.3×10^{-4} kg (b) -2.66×10^{-5} m

Numerical 4. Solve the following multiplication or division. State your answers in scientific notation.
(a) $(5 \times 10^4\ m) \times (3 \times 10^{-2}\ m)$ (b) $(6 \times 10^8\ kg) \div (3 \times 10^4\ m^3)$

STEP-BY-STEP SOLUTION

(a) Multiply the numbers and add the powers of ten:
$(5 \times 3) \times 10^{(4-2)} = 15 \times 10^2\ m^2 =$ **$1.5 \times 10^3\ m^2$**

(b) Divide the numbers and subtract the powers of ten:
$(6 \div 3) \times 10^{(8-4)} =$ **$2.0 \times 10^4\ kg\ m^{-3}$**

Final Answer: (a) $1.5 \times 10^3\ m^2$ (b) $2.0 \times 10^4\ kg\ m^{-3}$

Numerical 5. Calculate the following and state your answer in scientific notation: $(3 \times 10^2\ \text{kg}) \times (4.0\ \text{km}) \div (5 \times 10^2\ \text{s}^2)$

STEP-BY-STEP SOLUTION

First convert km to m: $4.0\ \text{km} = 4.0 \times 10^3\ \text{m}$.

Numerator $= (3 \times 10^2\ \text{kg}) \times (4.0 \times 10^3\ \text{m}) = 12 \times 10^5\ \text{kg·m} = 1.2 \times 10^6\ \text{kg·m}$

Now divide by $5 \times 10^2\ \text{s}^2$:
$(1.2 \times 10^6) \div (5 \times 10^2) = 0.24 \times 10^4 =$ **$2.4 \times 10^3\ \text{kg m s}^{-2}$**

Final Answer: $2.4 \times 10^3\ \text{kg m s}^{-2}$

Numerical 6. State the number of significant digits in each measurement.
(a) 0.0045 m (b) 2.047 m (c) 3.40 m (d) 3.420×10^4 m

STEP-BY-STEP SOLUTION

(a) 0.0045 m — leading zeros are not significant; only 4 and 5 count → **2 significant figures**
(b) 2.047 m — all non-zero digits and the zero between them are significant → **4 significant figures**
(c) 3.40 m — the trailing zero after the decimal point is significant → **3 significant figures**
(d) 3.420×10^4 m — all digits in the coefficient 3.420 are significant → **4 significant figures**

Final Answer: (a) 2 (b) 4 (c) 3 (d) 4

Numerical 7. Write in scientific notation: (a) 0.0035 m (b) 206.4×10^2 m

STEP-BY-STEP SOLUTION

(a) Move the decimal point 3 places right:
0.0035 m = **3.5×10^{-3} m**

(b) 206.4×10^2 m = $2.064 \times 10^2 \times 10^2$ m =
2.064×10^4 m

Final Answer: (a) 3.5×10^{-3} m (b) 2.064×10^4 m

Numerical 8. Write using correct prefixes: (a) 5.0×10^4 cm (b) 580×10^2 g (c) 45×10^{-4} s

STEP-BY-STEP SOLUTION

(a) 5.0×10^4 cm = 5.0×10^2 m = 500 m = **0.5 km**

(b) 580×10^2 g = 58 000 g = 58×10^3 g = **58 kg**

(c) 45×10^{-4} s = 4.5×10^{-3} s = **4.5 ms**

Final Answer: (a) 0.5 km (b) 58 kg (c) 4.5 ms

Numerical 9. A light year is a unit of distance used in Astronomy. It is the distance covered by light in one year. Taking the speed of light as 3.0×10^8 m s^{-1}, calculate the distance.

STEP-BY-STEP SOLUTION

Time in one year ≈ 365 days × 24 h × 3600 s
= 3.1536×10^7 s

Distance = speed × time
= $(3.0 \times 10^8 \text{ m s}^{-1}) \times (3.1536 \times 10^7 \text{ s})$
= **9.46×10^{15} m**

Final Answer: 9.46×10^{15} m

Numerical 10. Express the density of mercury given as 13.6 g cm^{-3} in kg m^{-3}.

STEP-BY-STEP SOLUTION

$13.6 \text{ g cm}^{-3} = 13.6 \times (1 \text{ kg} / 1000 \text{ g}) \times (100 \text{ cm} / 1 \text{ m})^3$

$= 13.6 \times (1/1000) \times (10^6) \text{ kg m}^{-3}$

$= 13.6 \times 10^3 \text{ kg m}^{-3}$ = **1.36×10^4 kg m^{-3}**

Final Answer: 1.36×10^4 kg m^{-3}

🎉 All Questions Solved!

Every MCQ, short answer, constructed response, comprehensive question and numerical problem from this exercise has been answered and explained step by step. Revise section by section and you'll have Chapter 1 — Measurements fully mastered.