Class 9 Physics

Chapter 1 — Physical Quantities and Measurement

Constructed Response Questions (Exercise C) — Solved

C 1.1. In what unit will you express each of the following?

We choose a unit whose size is close to the quantity being measured, so the numerical value is neither too large nor too small. Each practical unit can still be converted to the SI base unit (metre, kilogram, second).

Quantity	Suitable unit	In SI base unit
Thickness of a five-rupee coin	millimetre (mm)	1 mm = 10^{-3} m
Length of a book	centimetre (cm)	1 cm = 10^{-2} m
Length of a football field	metre (m)	SI base unit
Distance between two cities	kilometre (km)	1 km = 10^{3} m
Mass of a five-rupee coin	gram (g)	1 g = 10^{-3} kg
Mass of a school bag	kilogram (kg)	SI base unit
Duration of a class period	minute (min)	1 min = 60 s
Volume of petrol in a car tank	litre (L)	1 L = 10^{-3} m^3
Time to boil one litre of milk	minute (min)	1 min = 60 s

C 1.2. Why might a standard system of measurement be helpful to a tailor?

A tailor's whole work depends on accurate, repeatable lengths — chest, waist, sleeve, shoulder, shirt and trouser length. A standard system of measurement (metre and centimetre) makes every such measurement mean exactly the same thing to everyone.

Its main benefits are: (1) accuracy and fit — cloth is cut to exact sizes so the garment fits; (2) reproducibility — the same size can be made again months later from written measurements; (3) fair trade — cloth is bought and sold by the metre, so neither side is cheated; (4) clear communication — the tailor, the customer and other tailors all understand "90 cm" identically; (5) less waste and cost — accurate measuring avoids cutting cloth wrongly.

If each tailor used a personal unit such as his own hand-span, the same "size" would differ from person to person, clothes would not fit, and standard ready-made sizes (S, M, L) would be impossible. A standard system therefore gives uniformity, accuracy and consistency.

C 1.3. Micrometer screw gauge — least count and thickness of the rod.

A micrometer works on the principle of a screw: when the thimble makes one complete rotation, the spindle advances along the main scale by a distance equal to the pitch.

Given: pitch = 1 mm (advance per rotation); number of divisions on the circular scale, N = 100.

Least count = pitch ÷ N = 1 mm ÷ 100 = 0.01 mm = 0.001 cm

This is why a micrometer reads to 0.01 mm — ten times finer than a Vernier Callipers (0.1 mm). The thickness is found as:

Thickness = main-scale reading + (circular-scale division × least count)

From the figure, main-scale reading = 7 mm and circular-scale reading = 68 divisions, so:

Thickness = 7 + (68 × 0.01) = 7 + 0.68 = 7.68 mm = 0.768 cm

(If the gauge had a zero error, it would be subtracted from this value. The least count 0.01 mm is the definite result; the two-scale read-offs are taken from the figure.)

C 1.4. Measuring a pencil's diameter with a metre scale to Vernier precision.

The least count of a metre scale is 1 mm, so a single small diameter cannot be read more precisely than 1 mm. Accuracy is increased by measuring many identical pencils together and averaging. Place n identical pencils tightly in a row (no gaps), measure the total width W with the metre scale, then:

d = W ÷ n

Because we divide by n, the 1 mm uncertainty of the scale is also divided by n:

Effective least count = 1 mm ÷ n

For n = 10, the effective least count = 0.1 mm, equal to that of a Vernier Callipers. Example: if 10 pencils measure W = 70 mm, then d = 70 ÷ 10 = 7.0 mm, now good to 0.1 mm. Thus, averaging over 10 pencils gives a simple metre scale the precision of a Vernier Callipers.

C 1.5. The end of a metre scale is worn out — where will you place the pencil?

The worn (zero) end gives unreliable readings, so do not measure from it. Place one end of the pencil at a clear, sharp division — say 10.0 cm — and read the position of the other end. Then:

Length = (final reading) − (initial reading)

For example, from 10.0 cm to 25.0 cm the length = 25.0 − 10.0 = 15.0 cm. Because both readings are taken from good, sharp marks rather than the damaged end, the error of the worn end is completely cancelled — the same idea as removing a zero error by subtraction.

C 1.6. Why is it better to place the object close to the metre scale?

Parallax is the apparent shift in an object's position when the eye is not directly in line with it. If there is a gap between the object and the scale, and the eye is even slightly off the vertical, the line of sight meets the scale at a shifted point and the reading is wrong. The larger the gap and the greater the tilt of the eye from the perpendicular, the larger this parallax error.

When the object touches the scale (gap ≈ 0), the object and its scale mark lie in the same plane, so there is no shift even if the eye moves a little. Therefore, the object is kept close to the scale and viewed perpendicularly (line of sight at 90° to the scale) to eliminate parallax error and read the true length.

C 1.7. Why is a standard unit needed to measure a quantity correctly?

To measure is to compare a quantity with a unit, so every measurement is: quantity = numerical value × unit, that is:

$$\mathbf{Q = n \times u \text{ (for a given quantity, } n \times u = \text{constant)}}$$

So, the number n depends entirely on the unit u. If the unit is not fixed, the same quantity gives different numbers to different people and the measurement cannot be compared or trusted. A good standard unit must be well-defined, constant (unchanging with time, place or conditions), easily reproducible, internationally accepted and of convenient size. Because a standard unit satisfies these, the measured value is correct, unique and the same everywhere — for example, a hand-span differs from person to person, but 1 metre is identical in every country.

C 1.8. Natural phenomena that could serve as a reasonably accurate time standard.

A time standard needs a phenomenon that repeats with a constant, well-defined period T (frequency f = 1/T). Suitable natural phenomena include: the rotation of the Earth about its axis (the day); the revolution of the Earth around the Sun (the year ≈ 365.25 days); the phases/revolution of the Moon (the month ≈ 29.5 days); the rising and setting of the Sun (day and night); and the swinging of a simple pendulum of fixed length, whose period is:

$$\mathbf{T = 2\pi \sqrt{(L \div g)}}$$

(a fixed length L gives a fixed T — used in pendulum clocks); the vibrations of a quartz crystal (wrist watches); and the natural vibrations of a cesium-133 atom — the SI second is defined as the time for 9,192,631,770 such vibrations, the most accurate modern standard. The more constant and reproducible the period, the more accurate the time standard.

C 1.9. It is difficult to locate the meniscus in a wider vessel. Why?

Because of surface tension, the free surface of a liquid curves near the container walls, forming a meniscus (concave for water, convex for mercury); the reading is taken at its lowest point (for water). In a narrow tube the walls are close together, so the curvature is strong, the meniscus is deep and sharply defined, and its lowest point is easy to locate.

In a wide vessel the walls are far apart, so the surface is almost flat with a very large radius of curvature; the meniscus becomes broad, shallow and poorly defined, and its lowest point cannot be fixed precisely. Hence the liquid level is hard to read accurately in a wide vessel — which is why measuring cylinders are made narrow.

C 1.10. Which instrument can measure (i) internal diameter of a test tube (ii) depth of a beaker?

Both are measured with a Vernier Callipers (least count 0.1 mm = 0.01 cm), using its different parts:

(i) Internal diameter of a test tube → the upper (inside) jaws are put into the tube and opened until they press against the walls; the reading gives the internal diameter.

(ii) Depth of a beaker → the thin depth rod (tail) at the end of the main scale is lowered to the bottom while the frame rests on the rim; the reading gives the depth.

Total reading = main-scale reading + (coinciding Vernier division × least count)