Unit 1 · Physical Quantities

HARDER PRACTICE QUESTIONS

Full marks 33

Write your answers on separate paper. Show your working.

1 Spot the error [3]

Find the mistake in the working and correct it.

Rishav converts the density of air, 1.2 kg/m^3, into g/cm^3. He writes:
"1 kg = 1000 g and 1 m = 100 cm, so 1.2 kg/m^3 = 1.2 × 1000 ÷ 100 g/cm^3 = **12 g/cm^3**."

2 Find the law [4]

Use the method of dimensions.

The time T a planet takes to go once round the Sun might depend on the radius r of its orbit, the mass M of the Sun and the gravitational constant G, whose dimensions are [M^{-1} L^3 T^{-2}].

i. Find how T depends on r, M and G.
ii. A planet's orbit is four times as wide as another's. How many times as long is its year?

3 Measure g with a pendulum [5]

Anisha uses a simple pendulum to find g from $T = 2\pi\sqrt{l/g}$. She measures the length as (100.0 ± 0.1) cm and times 20 swings: (40.2 ± 0.2) s.

i. Find g.
ii. Find the percentage uncertainty in g, and write g with its uncertainty.
iii. Which of her two measurements adds more to the uncertainty? How could she make it smaller without a better stopwatch?

4 Estimate it [3]

Estimate how many times your heart beats in a lifetime of 75 years, at about 70 beats a minute. Give your answer to one significant figure and as an order of magnitude. Why would it be wrong to write all the digits your calculator shows?

5 What if? [3]

The length of a mercury column is found as the difference of two scale readings: (25.6 ± 0.1) cm and (24.9 ± 0.1) cm.

i. Find the length with its uncertainty and its percentage uncertainty.
ii. Each reading was uncertain by less than 0.5%. Explain why the answer is so much worse, and what this means for an experiment that subtracts two nearly equal readings.

6 Work backwards [3]

In a new system of units, the unit of mass is 10 kg, the unit of length is 10 m and the unit of force is 1 N. What must the unit of time be? Explain how you found it.

7 Which stopwatch? [3]

Two stopwatches time a clock's 10.00 s beep four times each.

Stopwatch	Readings (s)
A	10.31, 10.30, 10.32, 10.29
B	9.7, 10.4, 10.1, 9.9

i. Which stopwatch is more precise, and which more accurate on average? Give the mean of each.

ii. Which of the two errors would taking more readings and averaging reduce? Explain.

8 Correct the misconceptions [3]

The paragraph has three mistakes. Write each mistake and correct it.

Ujwal wrote: "The number 0.0500 has only one significant figure, because zeros never count. My calculator gave the answer 13.17528, so writing all those digits makes my answer more accurate. And since my equation is dimensionally correct, it must be right."

9 Think [4]

The period T of a mass m bouncing on a spring might depend on m, the spring constant k (a force per unit stretch, $[M\,T^{-2}]$) and the amplitude A of the bounce.

i. Use dimensions to find the relation.

ii. What does your answer say about a small bounce and a big one?

iii. Shivani says T might also depend on g. Show why dimensions alone can then no longer decide the relation.

10 Make your own [2]

Using v (final velocity), u (initial velocity), a (acceleration) and t (time), write one equation that is dimensionally correct but physically wrong, and one that is dimensionally wrong. Show which is which.