

COLLEGE PHYSICS

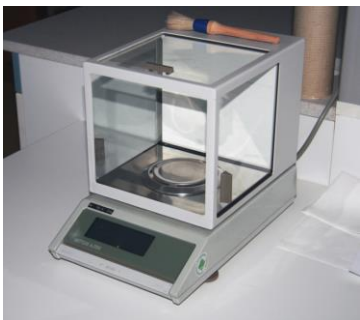
Chapter 1 INTRODUCTION: THE NATURE OF SCIENCE AND PHYSICS

Lesson 2

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MEASUREMENTS



- Here are two different kinds of scales, used to measure mass.
- Science depends on measurements.
- In real life, repeated measurements of the same thing are often **different**.
- That's because no measurement is exact; there is always a degree of uncertainty.

ACCURACY VS PRECISION

- **Accuracy** is how close a measurement is to the correct value for that measurement.
- The **precision** of a measurement system refers to how close the agreement is between repeated measurements (which are repeated under the same conditions).
- Precision is often specified by how many decimal places you report in the measurement.

ACCURACY VS PRECISION



Accurate, but not very precise.

$$\pi = 3$$



Precise, but not accurate.

$$\pi = 3.24159$$

Precise **and** accurate: $\pi = 3.14159$

UNCERTAINTY

- The range of values associated with a measurement can be described by a “plus-or-minus” **uncertainty**.



Exactly 3 apples
(uncertainty = zero)

1600 ± 100 apples:

1600 is the **value**
100 is the **uncertainty**



UNCERTAINTY

- By using a numerical uncertainty, you **eliminate** the need to report measurements with vague terms like “approximately” or “≈”.
- Uncertainties give a *quantitative* way of stating your confidence level in your measurement.
- Saying the answer is “1600 ± 100” means you are 68% confident that the actual number is between 1500 and 1700.

SIGNIFICANT FIGURES

- If you report a length as 6.2 m, you **imply** that the actual value is between 6.15 m and 6.25 m, and has been rounded to 6.2.
- The number 6.2 has *two* significant figures (“6” and “2”).
- More precise measurement could give more significant figures.
- The appropriate number of significant figures is determined by the data provided.

SIGNIFICANT FIGURES - ZEROS

- Special consideration is given to zeros when counting significant figures.
- The zeros in 0.053 are not significant, because they are only placekeepers that locate the decimal point.
- The zeros in 10.053 are not placekeepers but are significant.
- The zeros in 1300 may or may not be significant depending on the style of writing numbers.
- *Zeros are significant except when they serve only as placekeepers.*

Counting Sig Figs.

3.05 3 sig figs

→ 0.620 3

52,100 3 ?

52,100.0 6

5.21 × 10⁴ 3 ✓

5.001 4

↙ ↘ ↘ 0.0012 2

1.2 × 10⁻³ 2

GIVE IT A TRY!

Which of the following has the most number of significant figures?

- A. 8200
- B. 0.0052
- C. 0.430
- D. 4×10^{-23}
- E. 8000.01

SIGNIFICANT FIGURES IN CALCULATIONS

- When doing a calculation, the number of significant digits in the final answer can be no greater than the number of significant digits in the least precise measured value.
- There are two different rules, one for multiplication and division and the other for addition and subtraction, as discussed below.

SIGNIFICANT FIGURES IN CALCULATIONS

For multiplication and division: The result should have the same number of significant figures as the quantity having the *least* significant figures entering into the calculation.

For example, let's say the radius of a circle is known to two significant figures: $r = 1.2$ m.

The area of the circle is computed as $A = \pi r^2 = (3.1415927\dots) \times (1.2 \text{ m})^2 = 4.5238934 \text{ m}^2$

Because the radius has only two significant figures, it limits the calculated quantity to two significant figures or $A = 4.5 \text{ m}^2$, even though π is good to at least eight digits.

SIGNIFICANT FIGURES IN CALCULATIONS

For addition and subtraction: *The answer can contain no more decimal places than the least precise measurement.*

For example, suppose that you add three masses:
 $7.56 \text{ kg} + 6.052 \text{ kg} + 13.7 \text{ kg} = 15.208 \text{ kg}$.

The least precise measurement, 13.7 kg, is expressed to the 0.1 decimal place, so our final answer must also be expressed to the 0.1 decimal place.

Thus, the answer is rounded to the tenths place, giving us 15.2 kg.

Problem You travel 163.1 m in 120 s. What was your average speed?

$$\underline{d} = \underline{163.1} \text{ m} \quad 4$$

$$\underline{t} = \underline{120} \text{ s} \quad 2$$

$$v = \frac{d}{t} = \frac{163.1}{120}$$

$$= 1.359166667$$

$$= \boxed{1.4 \frac{\text{m}}{\text{s}}}$$

GIVE IT A TRY!

A cart begins at rest, and accelerates down a ramp with acceleration: $a = 0.518 \text{ m/s}^2$. After 3.2 s, how far has it traveled? $d = \frac{1}{2} a t^2$ gives the result 2.65216 on your calculator. How should you best report this answer in your "Final Answer" box?

- A. 2.65216 m
- B. 2.65 m
- C. 2.60 m
- D. 2.6 m
- E. 2.7 m

EXAMPLE PROBLEM - ROUNDING

A cart begins at rest, and accelerates down a ramp with acceleration: $a = 0.518 \text{ m/s}^2$.

After 3.2 s, how far has it traveled?

Use $d = \frac{1}{2} a t^2$.

$$t = 3.2 \text{ s}$$

$$t^2 = 10.24 \text{ s}^2$$

$$d = 0.5 (0.518)(10.24)$$

$$d = 2.65216 \text{ m}$$

$$d =$$

EXAMPLE PROBLEM – ROUNDING EARLY

A cart begins at rest, and accelerates down a ramp with acceleration:

$$a = 0.518 \text{ m/s}^2.$$

After 3.2 s, how far has it traveled?

$$t = 3.2 \text{ s}$$

Use $d = \frac{1}{2} a t^2$.

$$t^2 = 10.24 \text{ s}^2$$

Let's round t^2 to 10 s

$$d = 0.5 (0.518) (10)$$

$$= 2.59 \text{ m}$$

$$d = 2.6 \text{ m} \leftarrow \text{This is wrong}$$