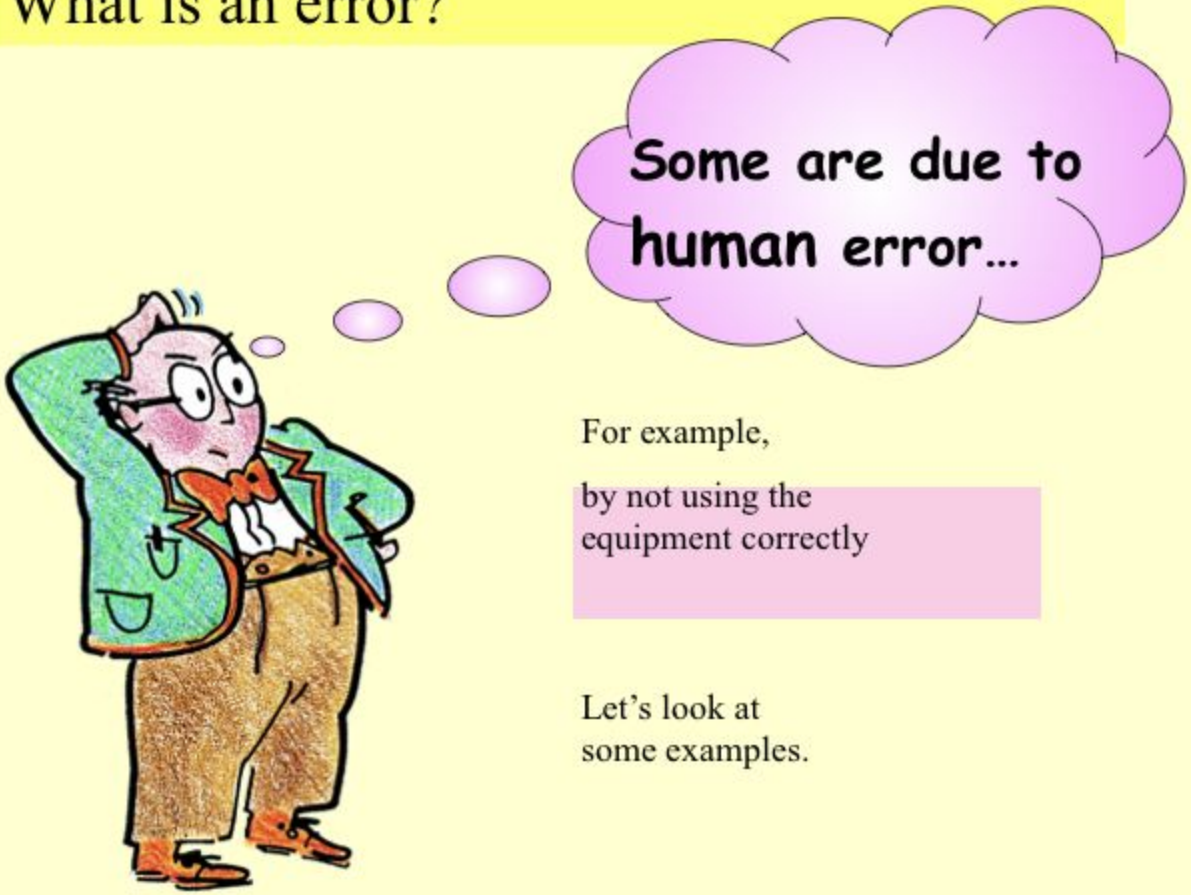
What is an error?



For example,

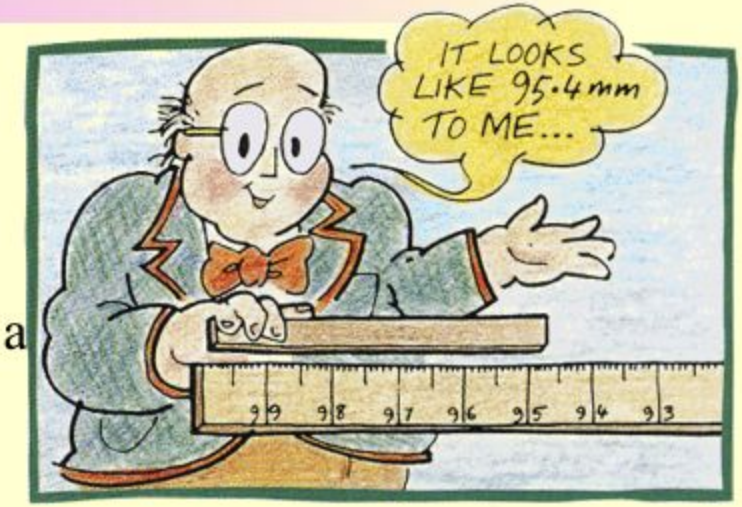
by not using the equipment correctly

Let's look at some examples.

Human error

Example 1

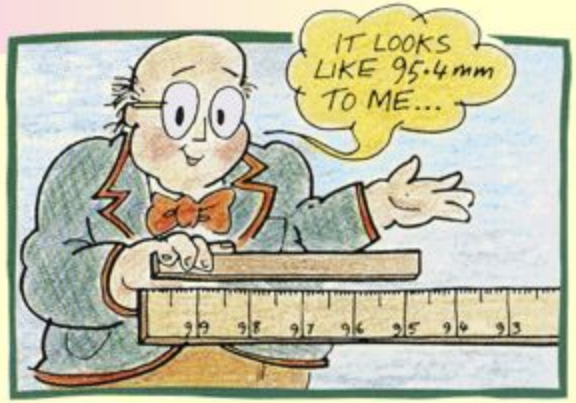
Professor Messer
is trying to
measure the length of a
piece of wood:



Discuss what he is doing wrong.

How many mistakes
can you find? Six? Seven?

Human error



Answers:

1. Measuring from 100 end
2. 95.4 is the wrong number
3. ‘mm’ is wrong unit (cm)
4. Hand-held object, wobbling
5. Gap between object & the rule
6. End of object not at the end of the rule
7. Eye is not at the end of the object (parallax)
8. He is on wrong side of the rule to see scale.

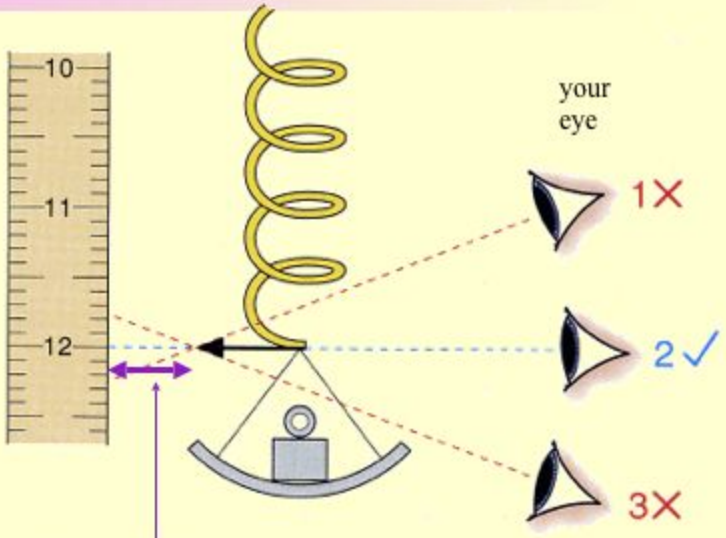
How many did you find?

Human error

2 is best.

1 and 3 give the wrong readings.

This is called a parallax error.

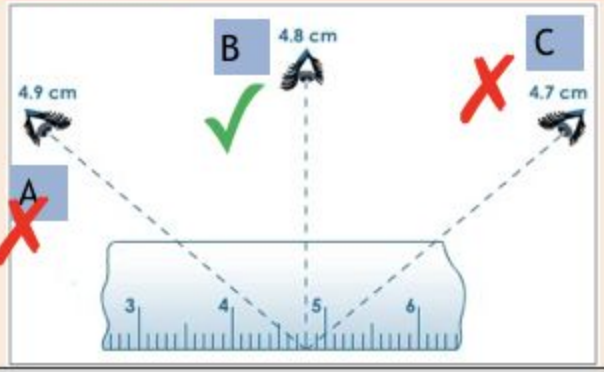


It is due to the gap here, between the pointer and the scale.

Should the gap be wide or narrow?

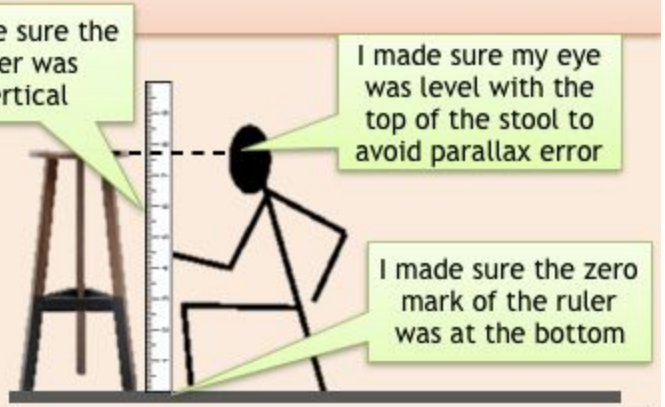
LO 1: Use and describe the use of rules and measuring cylinders to find a length or a

The key idea is to avoid **parallax error**. The eye should be placed so that it is **directly opposite** the scale.



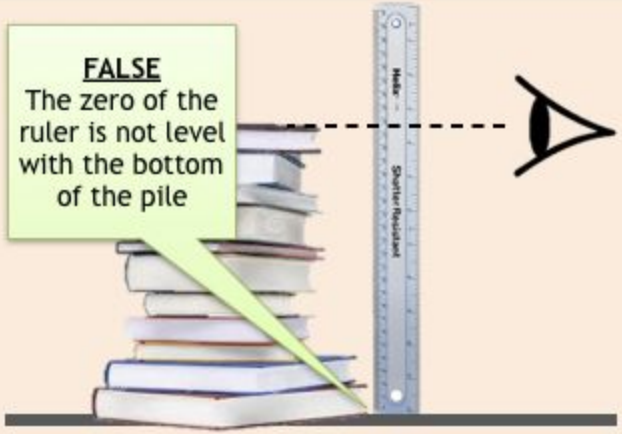
A1 Avoiding Parallax Error

1. Use a meter rule to measure the height of a stool to the nearest mm.
2. Draw a labeled diagram to explain how you measured this value as precisely as possible.



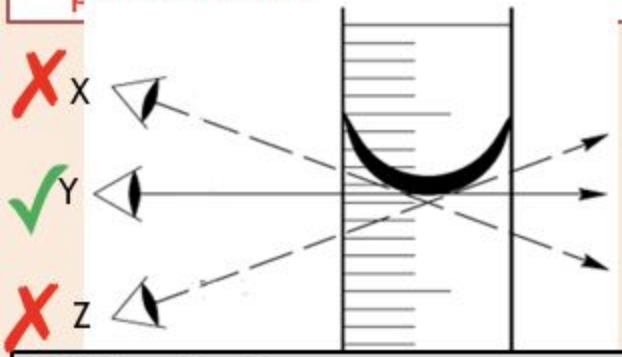
A2 TRUE OR FALSE

This pile of books is 21.4 cm high.



LO 1: Use and describe the use of rules and measuring cylinders to find a length or a volume

- Surface tension in a measuring cylinder produces a noticeable **meniscus** (a curved surface)
- You should always use the **bottom** of the meniscus to measure volume.
- The eye should be placed directly opposite the scale to avoid parallax error



A3 High or Low?
Measure the volume of water in the beaker.
Position X will produce a reading that is ~~too~~ high / low.
Position Y will produce a reading that is too ~~high~~ / low.

A4 The Great CocaCola RIP-OFF?
Coca-Cola claim that each can contains 330 ml of product.

Are they correct? Let's get three cans at random and check...

Can	Volume / ml
1	
2	
3	

Can we sue?

e

No.
The e symbol stands for "estimated". The law allows the volume of any one can to be ± 3 % of the nominal volume i.e. ± 10 ml as long as the average of all cans is equal to label.

Types of errors

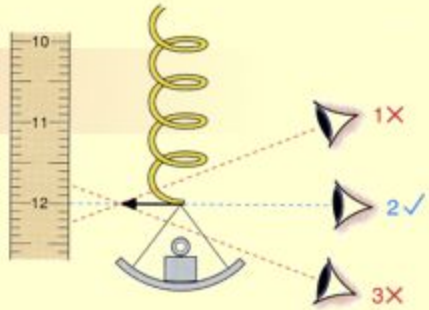
When reading scales,
there are 2 main types of error:

- Random errors
- Systematic errors.

Let's look at some examples . . .

Random errors

These may be due to
human error,
a faulty technique,
or faulty equipment.



When timing a pendulum
you may start the stopwatch
too soon, or too late, randomly.

Random errors

To reduce the error, take a lot of readings, and then calculate the average (mean).

For example, suppose the 6 results from timing 20 swings of a pendulum are:
21.7s 21.5s 22.1s 21.5s 21.6s 21.8s

We can get a more accurate value by calculating the mean (average), like this:

Time for 20 swings

$$= \frac{21.7 + 21.5 + 22.1 + 21.5 + 21.6 + 21.8}{} = \underline{21.7\ \text{s}}$$

Systematic errors

These errors cause readings to be shifted one way (or the other) from the true reading.

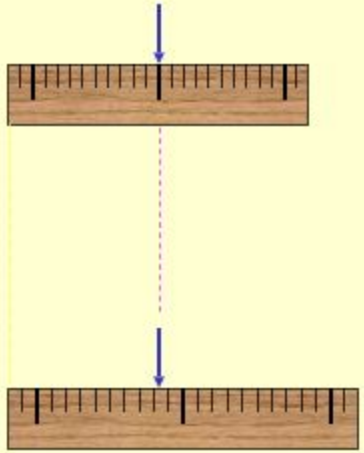
Your results will be systematically wrong.

Let's look at some examples . . .

Systematic errors

Example 1

Suppose you are measuring with a ruler:



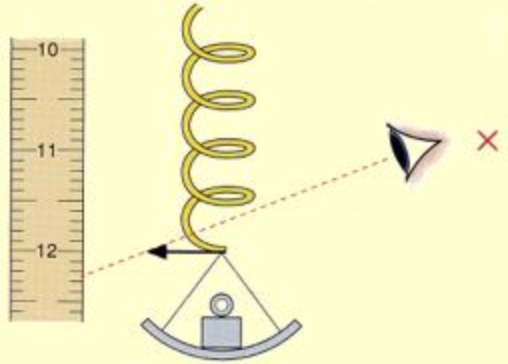
If the ruler is wrongly calibrated, or if it expands,

then all the readings will be too low (or all too high):

Systematic errors

Example 2

If you have a parallax error:



with your eye always too high

then you will get a systematic error

All your readings will be too high.

Systematic errors

A particular type of systematic error

is called a zero error.

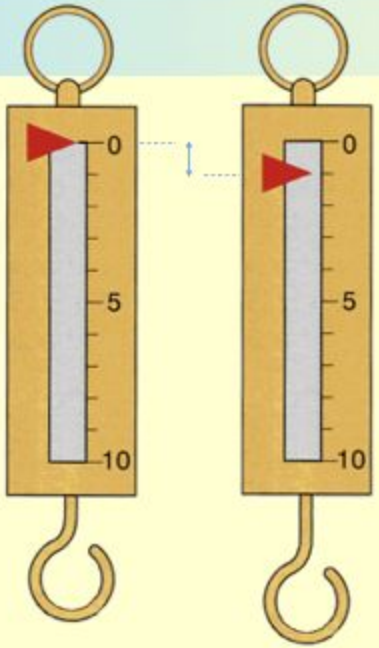
Here are some examples . . .

Zero errors

Example 3

A spring balance:

Over a period of time,
the spring may weaken,
and so the pointer
does not point to zero:



What effect does this have on all the readings?

Zero errors

Example 4

Look at this
top-pan balance:

It has a zero error.

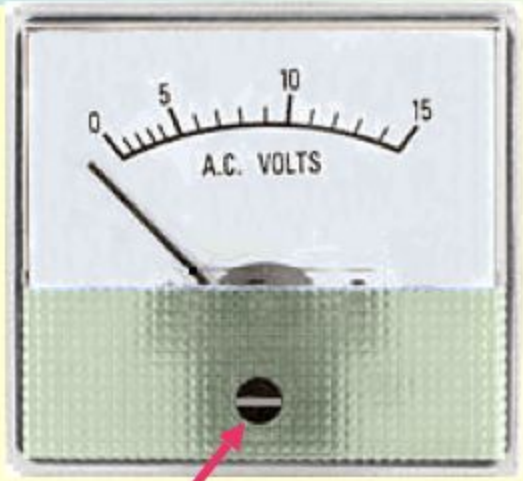
There is nothing on it,
but it is not reading zero.

What effect do you think this will have
on all the readings?

Zero errors

Example 6

Look at this voltmeter:



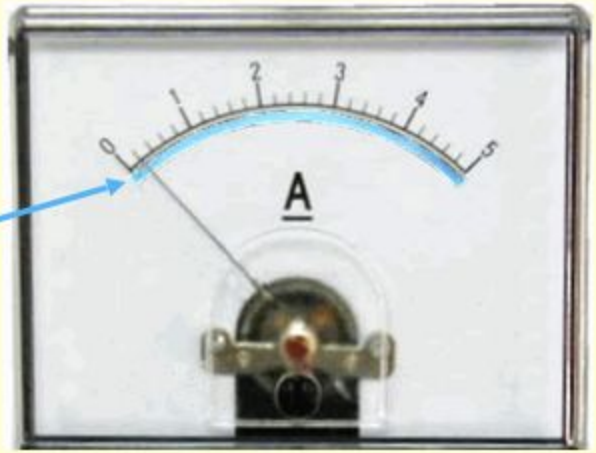
What is the first thing to do?

Use a screwdriver here to adjust the pointer.

Zero error, Parallax error

Example 8

Look at this ammeter:



It has a mirror
behind the pointer,
near the scale.

What is it for?

When the image of the pointer in the mirror
is hidden by the pointer itself,
then you are looking at 90°, with no parallax.

In summary

- Human errors can be due to faulty technique.
- Parallax errors can be avoided.
- Anomalous results can be seen on a graph.
- Random errors can be reduced by taking many readings, and then calculating the average (mean).
  The uncertainty is half the range.
- Systematic errors, including zero errors, will cause all your results to be wrong.