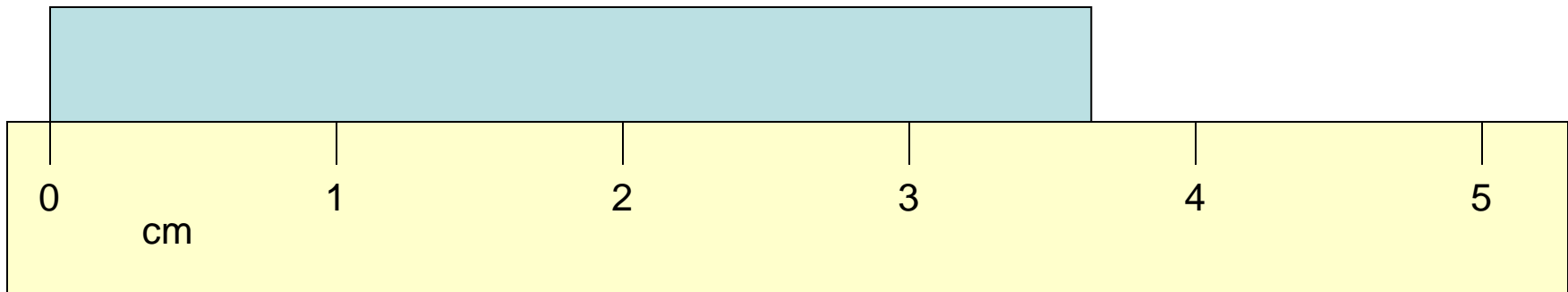


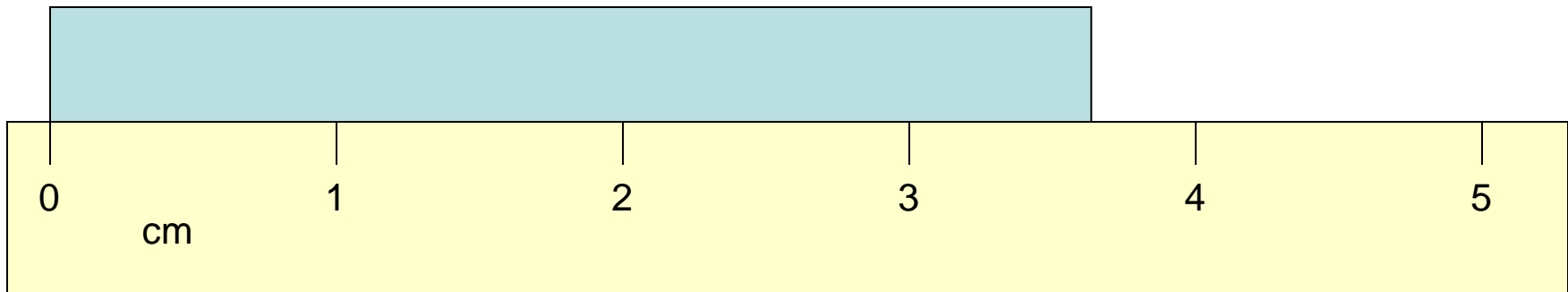
Making Measurements

On a piece of scrap paper, write down an appropriate reading for the length of the blue rectangle shown below: (then continue...)



Making Measurements

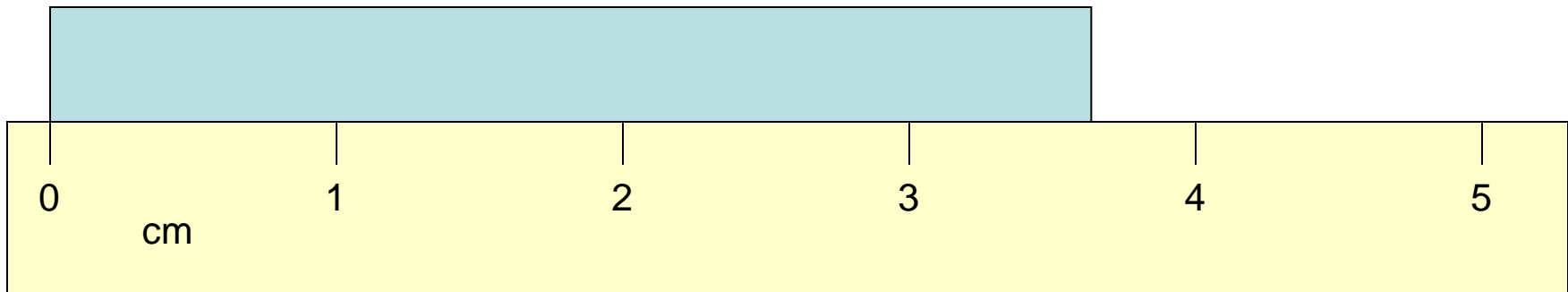
If the measurement you made was 3.7 cm (or 3.6 cm or 3.8 cm), congratulations! You read the scale correctly.



Making Measurements

3.7 cm

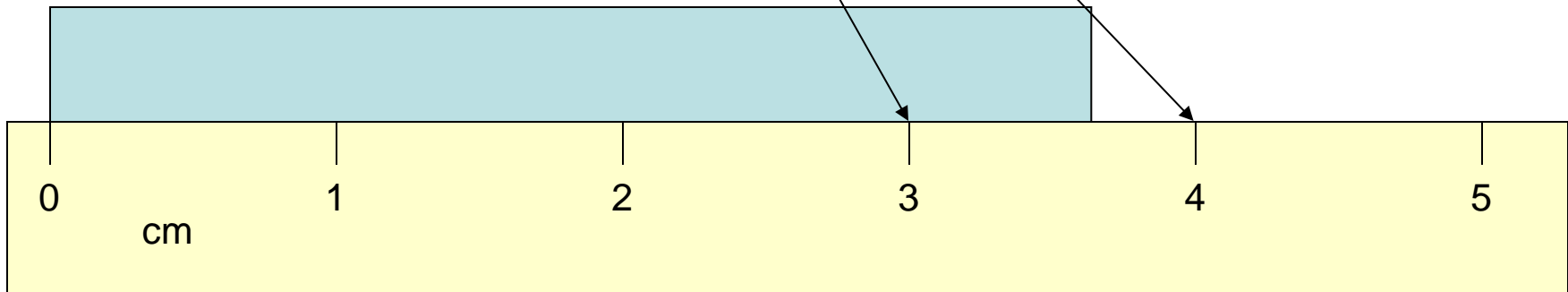
Notice how there are three distinct parts to this measurement:



Making Measurements

3.7 cm

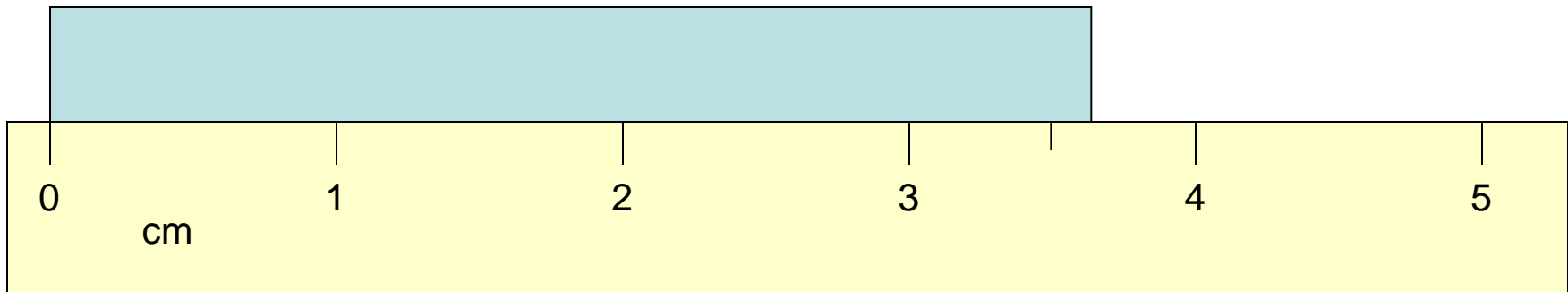
- 1) Magnitude: You can see that the length is somewhere between 3 and 4, so the measurement should be 3-point-something.



Making Measurements

3.7 cm

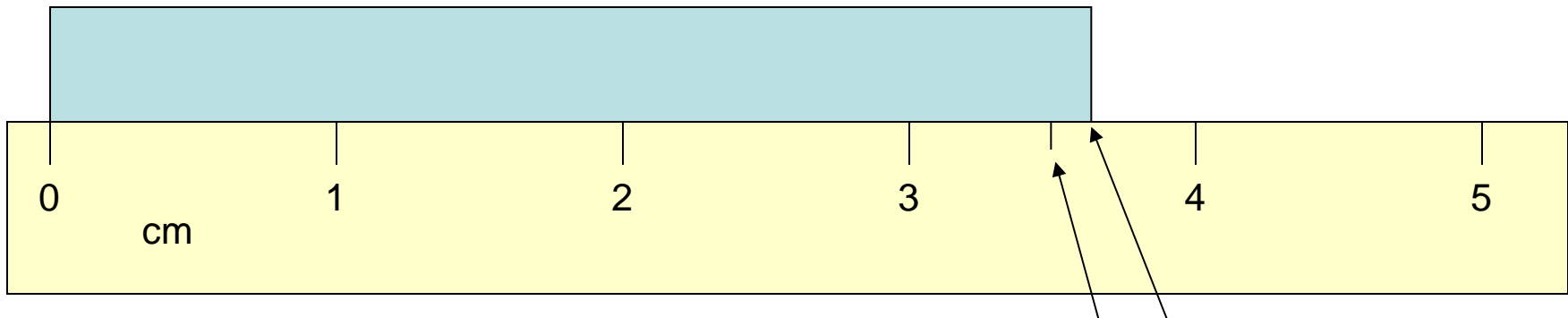
2) Precision: Since you are only allowed to guess one digit, you shouldn't just say "3" -- that doesn't have any guessed digits, and you shouldn't say "3.68" -- that has two guessed digits: the "6" and the "8."



Making Measurements

3.7 cm

2) Precision: Since you are only allowed to guess one digit, you shouldn't just say "3" -- that doesn't have any guessed digits, and you shouldn't say "3.68" -- that has two guessed digits: the "6" and the "8."

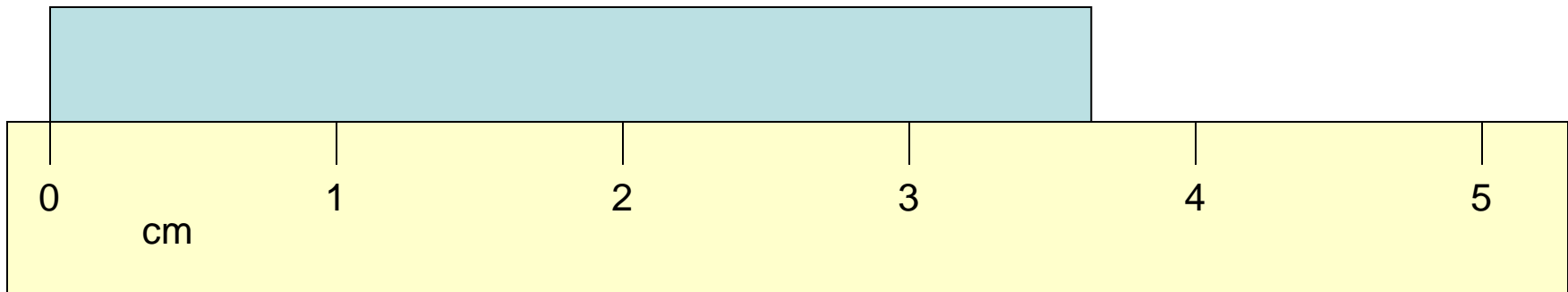


If we consider that 3.5 would be half-way between the 3 and the 4, and we can see that the edge of the rectangle extends well past the half-way point, an answer like 3.6 or 3.7 should make sense.

Making Measurements

3.7 cm

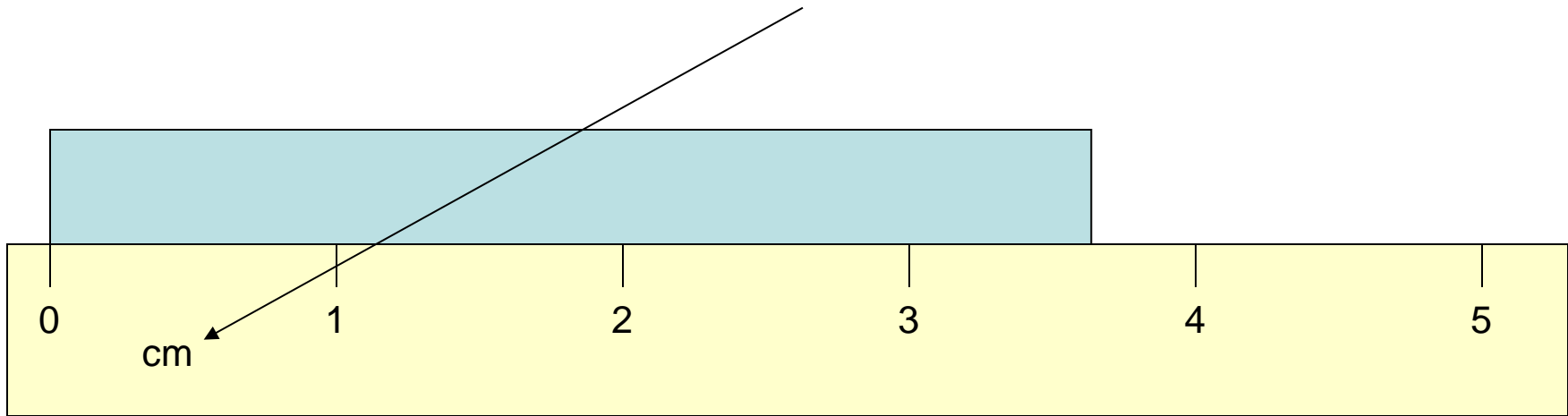
3) The unit: Without the “cm,” the measurement is meaningless... 3.7 what???



Making Measurements

3.7 cm

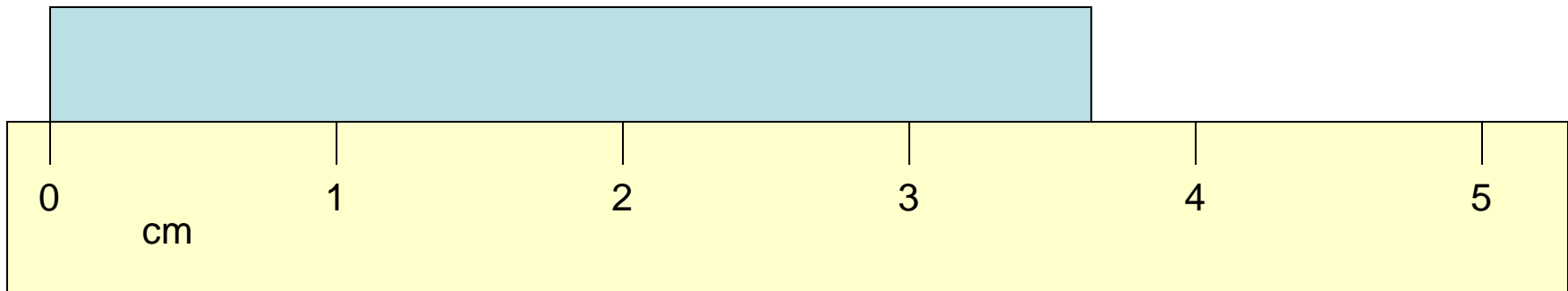
3) The unit: Without the “cm,” the measurement is meaningless... 3.7 what??? Every measuring device has the units printed clearly on it!



Making Measurements

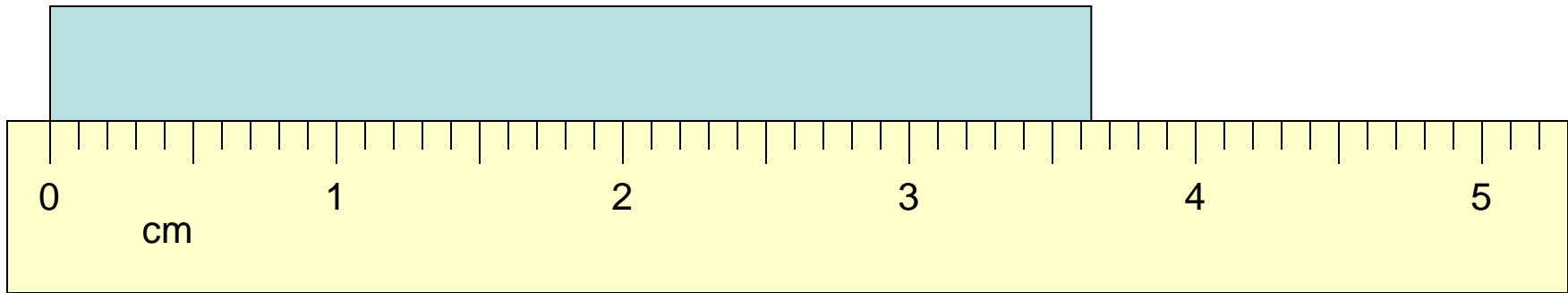
3.7 cm

3) The unit: Without the “cm,” the measurement is meaningless... 3.7 what??? Every measuring device has the units printed clearly on it! So always remember to include the unit with the measurement!



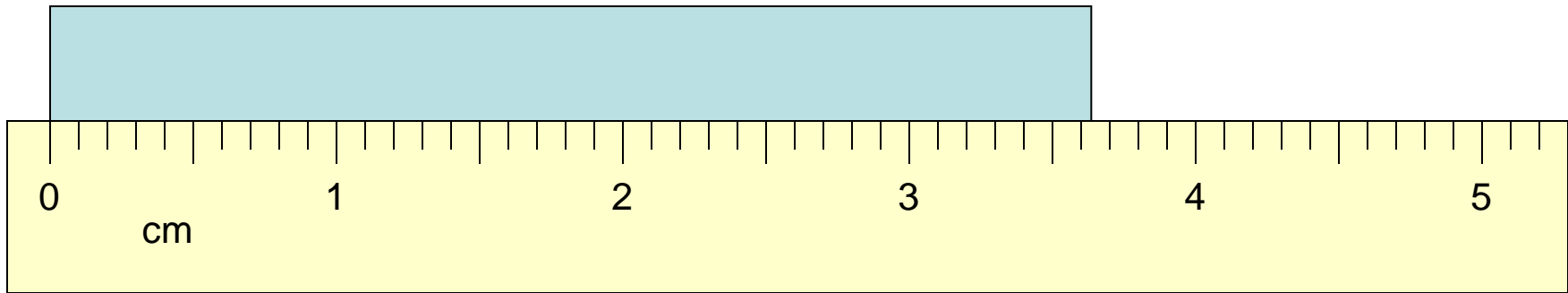
Making Measurements

Now let's measure the same rectangle with a better (more precise) ruler: write down an appropriate reading for the following measurement: (then continue...)



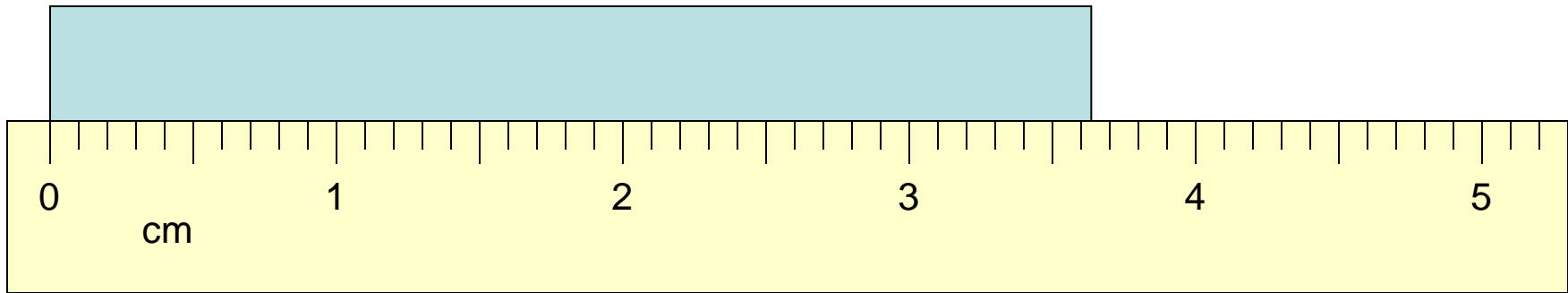
Making Measurements

Did you remember to include units on your answer!!!???



Making Measurements

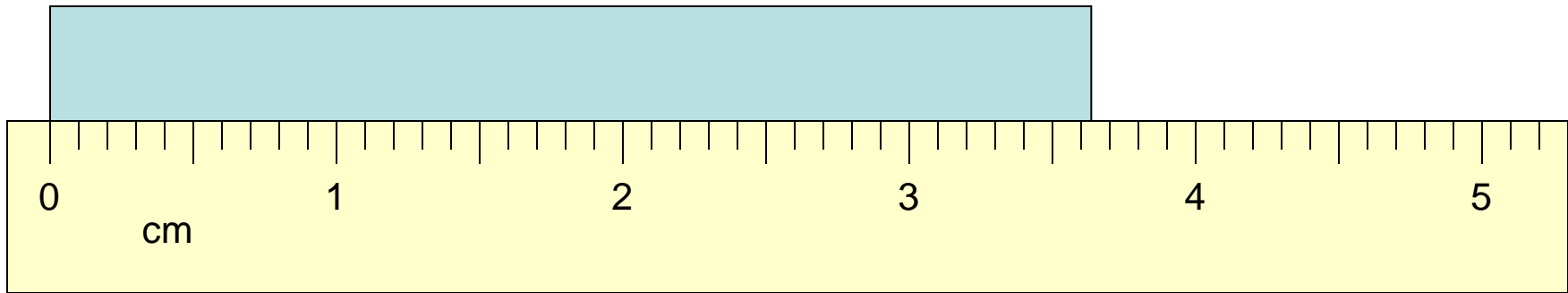
Was your answer “3.63 cm” – or “3.62 cm” or “3.64 cm?” If so, good job!



Making Measurements

3.63 cm

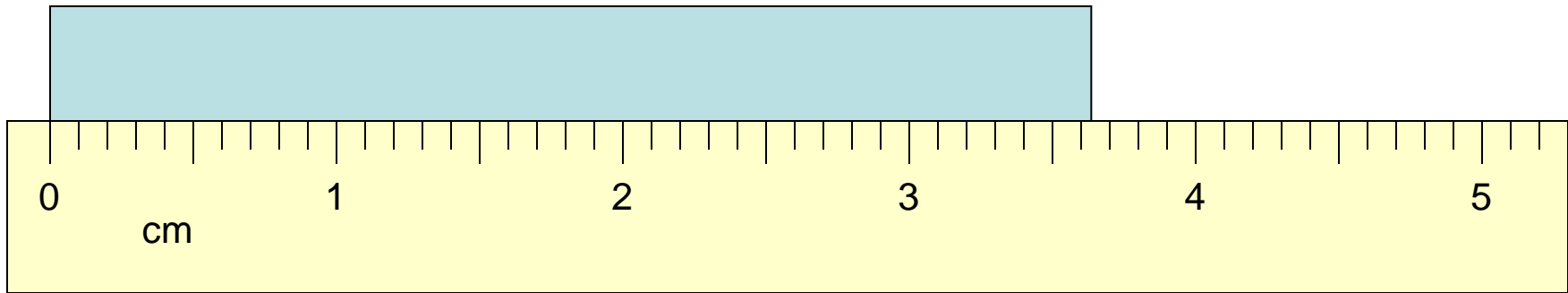
With this ruler, the scale is incremented every tenth of a cm...



Making Measurements

3.63 cm

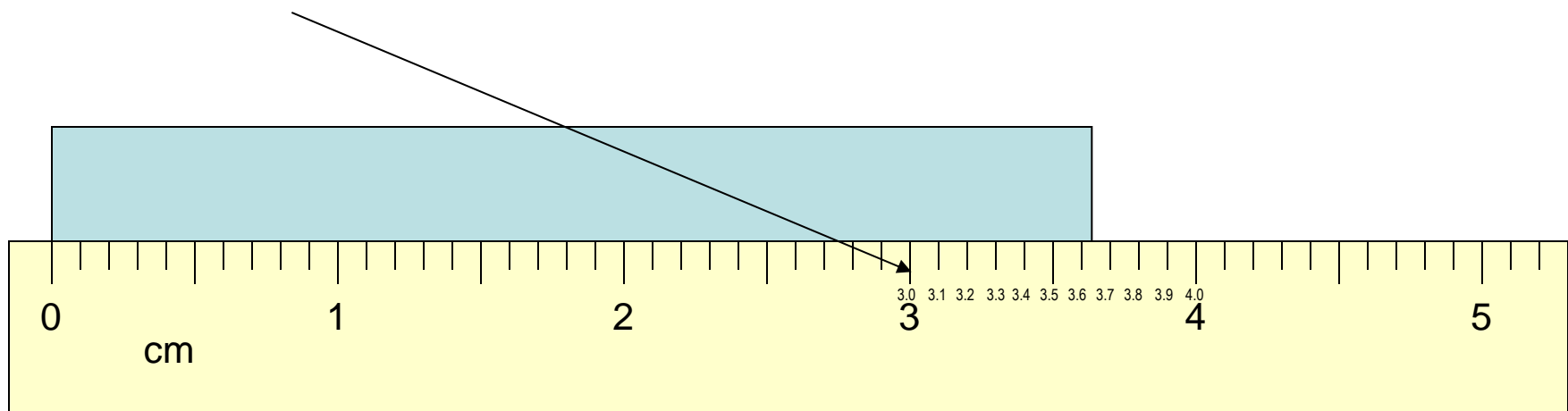
Although the in-between hash-marks are not labeled, if they were, they would look like this...



Making Measurements

3.63 cm

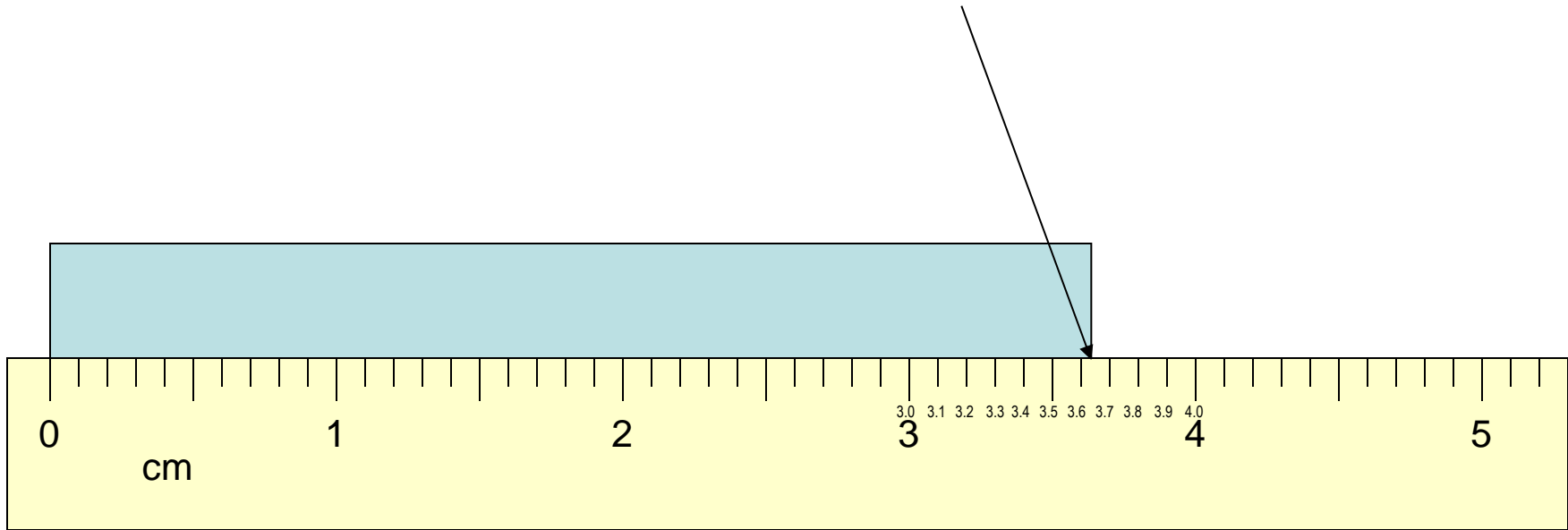
Although the in-between hash-marks are not labeled, if they were, they would look like this...



Making Measurements

3.63 cm

We can see that the end of the rectangle falls somewhere between the 3.6 and 3.7...

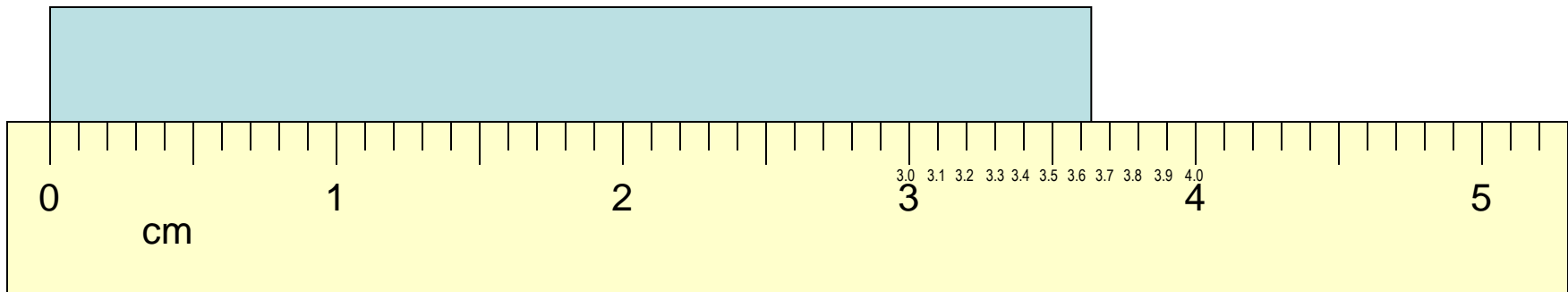


Making Measurements

3.63 cm

We can see that the end of the rectangle falls somewhere between the 3.6 and 3.7...

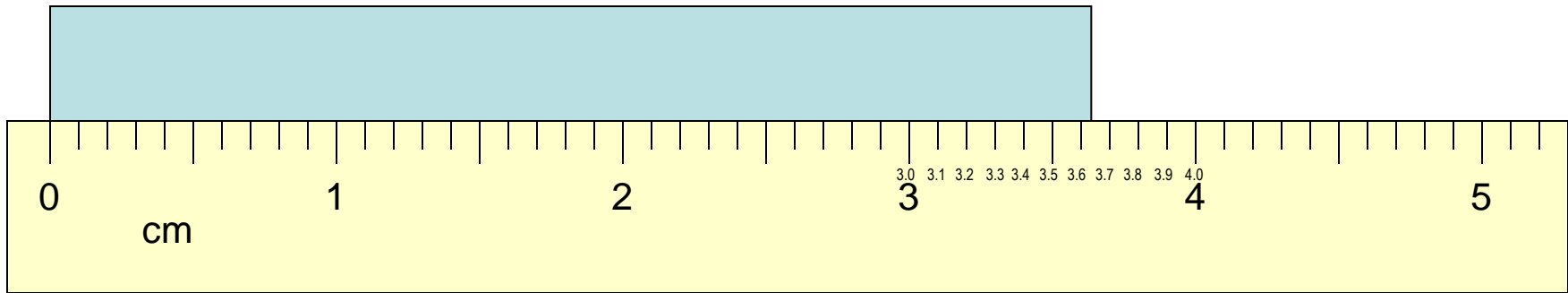
And since it extends less than halfway, it must be less than 3.65, so 3.63 should make sense.



Making Measurements

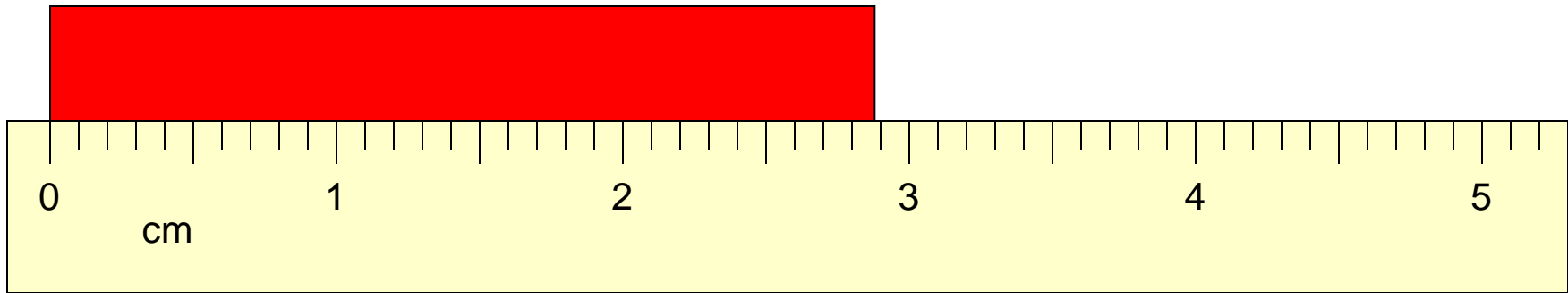
3.63 cm

Adding on the unit gives us “3.63 cm”



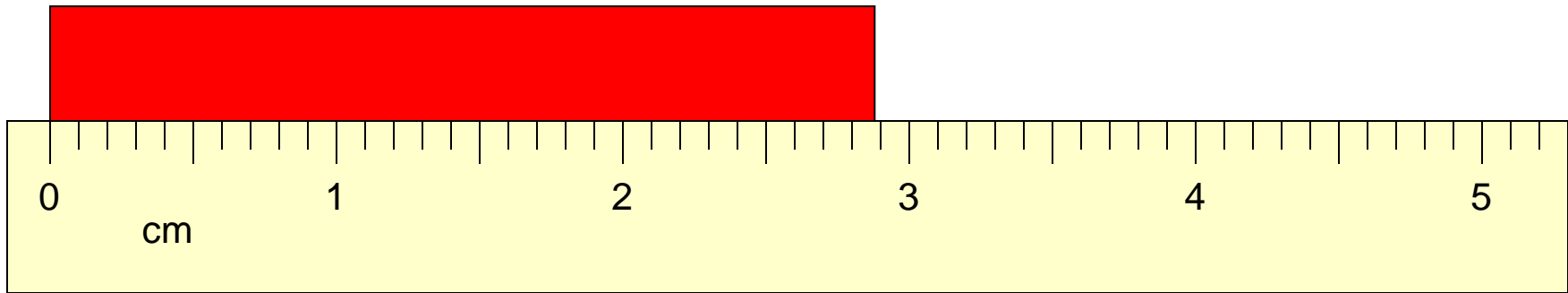
Making Measurements

Let's try some more measurements using this same ruler. On the scrap paper, write down the length of the red rectangle below: (then continue...)



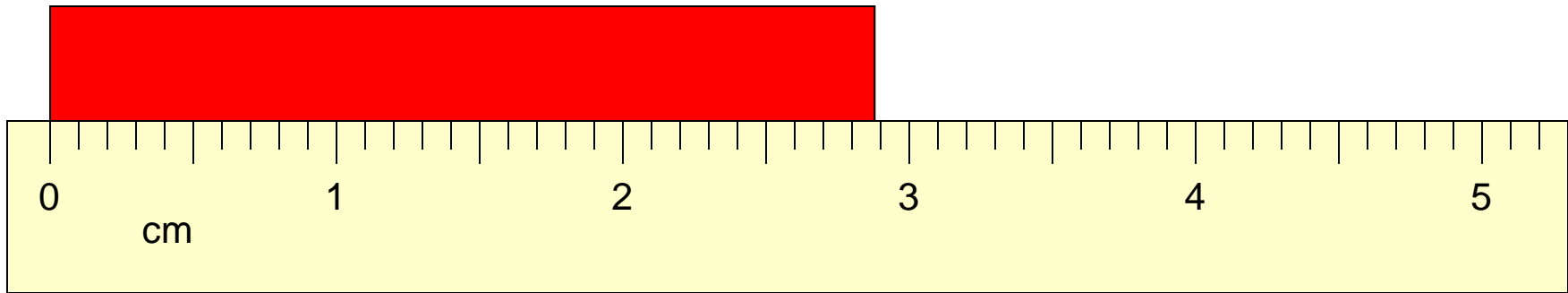
Making Measurements

Did you remember to include units!?



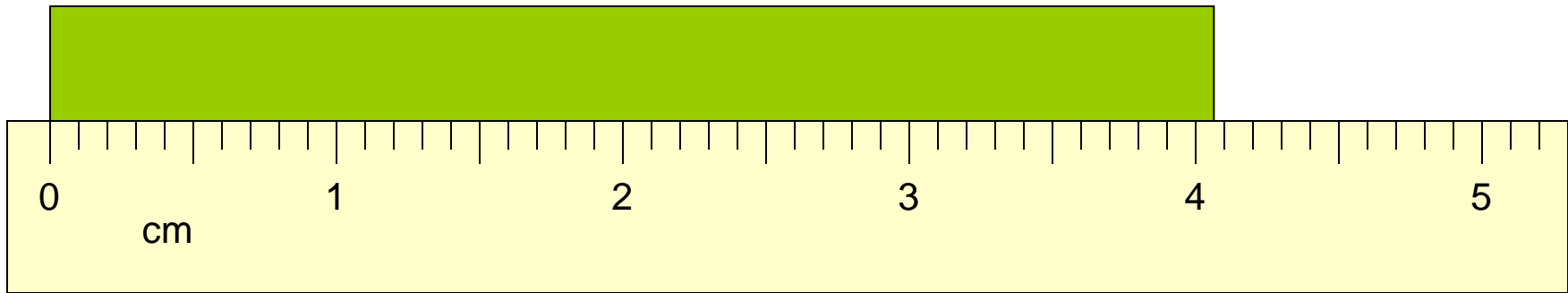
Making Measurements

And did you get “2.88 cm” -- or “2.87 cm” or “2.89 cm”? If so, you got it right!



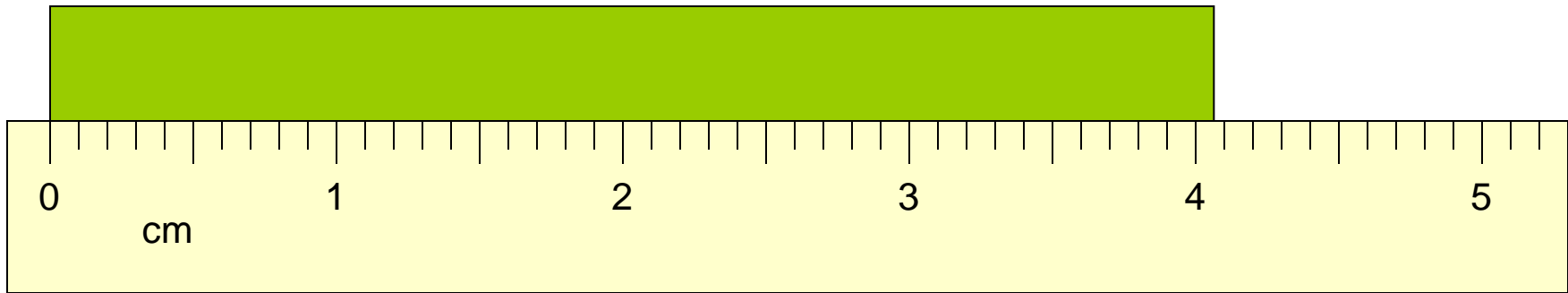
Making Measurements

Now try this one.



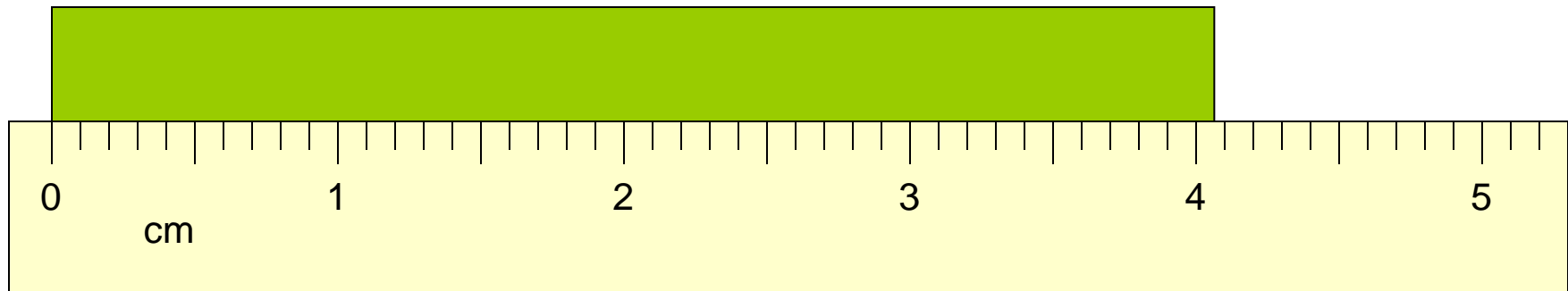
Making Measurements

Units????



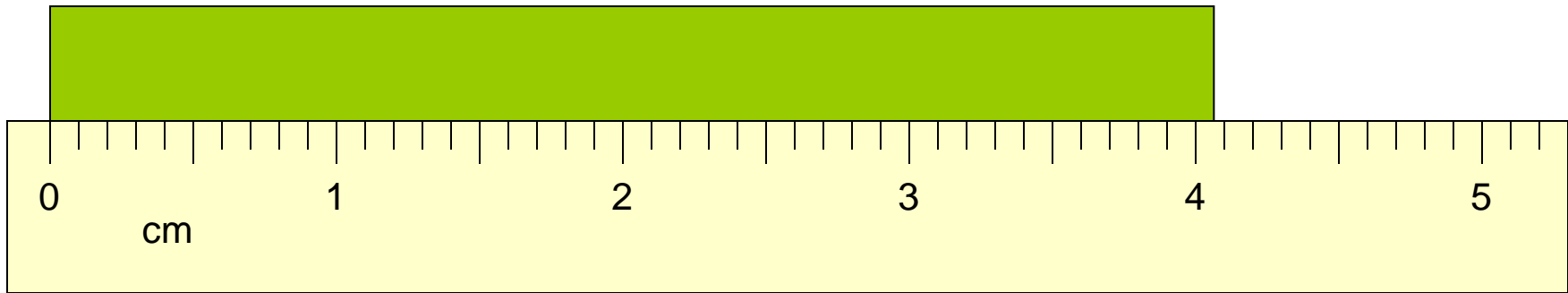
Making Measurements

Hopefully your answer was “4.05 cm” – or “4.04 cm” or “4.06 cm.”



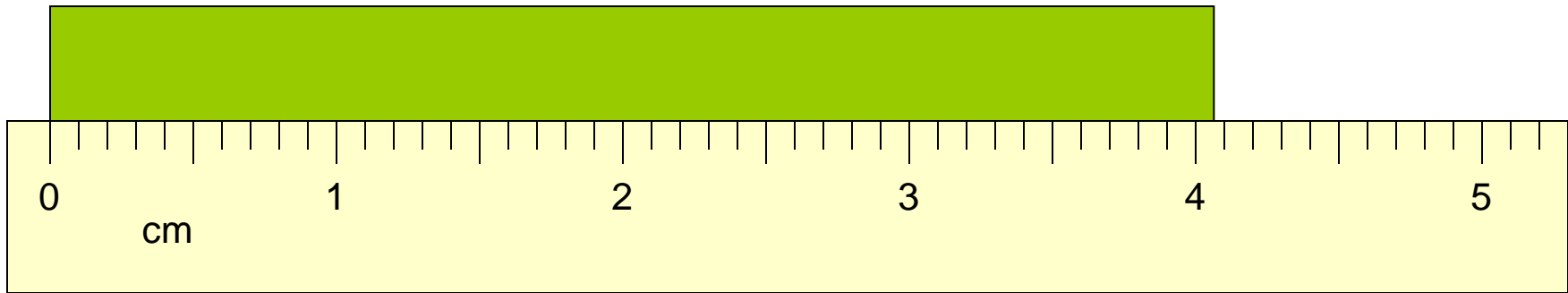
Making Measurements

“3.63 cm,” “2.88 cm,” “4.05 cm” What do these measurements all have in common?



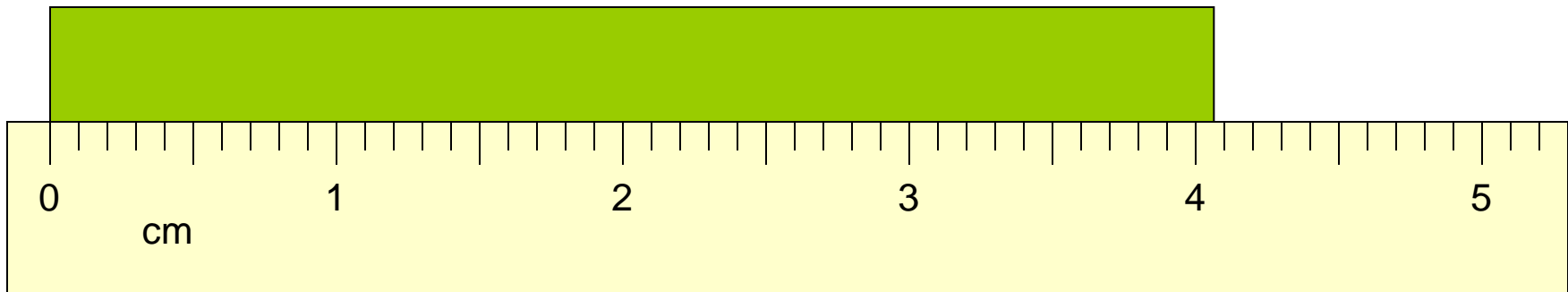
Making Measurements

“3.63 cm,” “2.88 cm,” “4.05 cm” What do these measurements all have in common? Yes, they are all in cm, but what else do they all have in common?



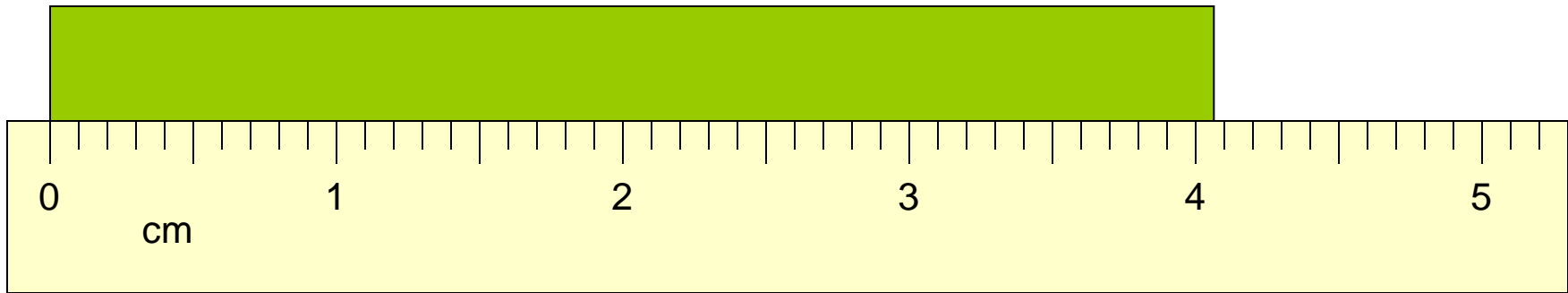
Making Measurements

“3.63 cm,” “2.88 cm,” “4.05 cm” What do these measurements all have in common? Yes, they are all in cm, but what else do they all have in common? That’s right: They are all read to the hundredths place.



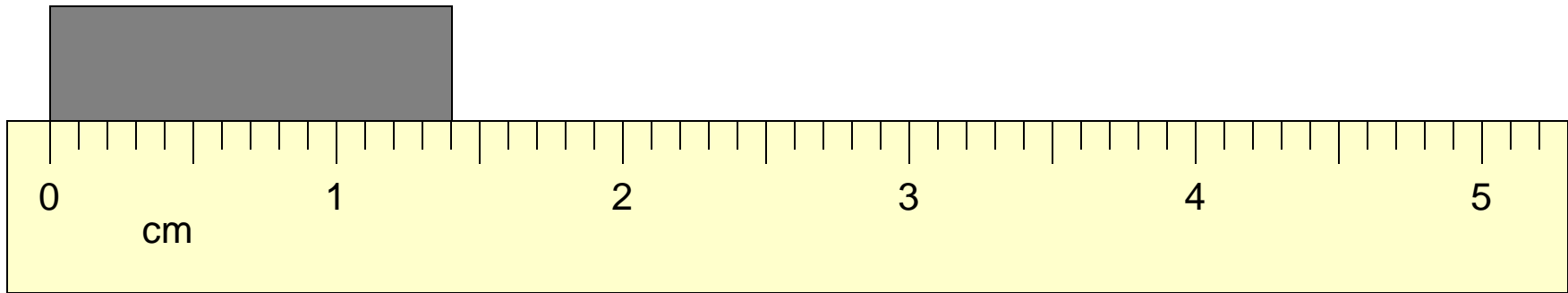
Making Measurements

In fact, since the scale is incremented to the tenths place, and since we should always guess one more digit on the end, it makes sense that every reading made with this scale should be to the hundredths place.



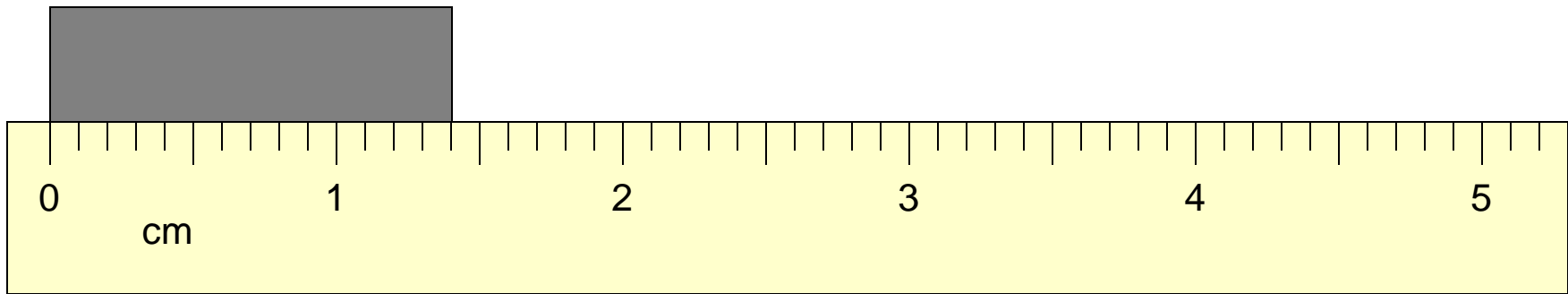
Making Measurements

So now try this one:



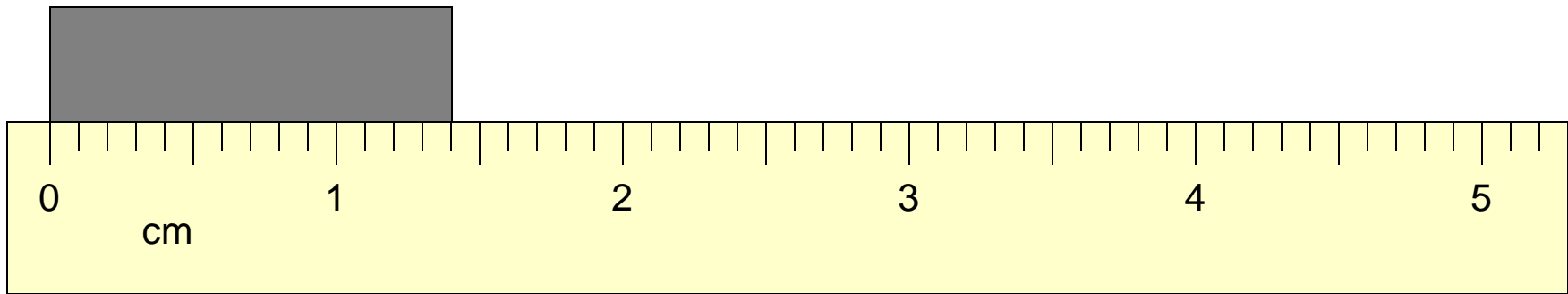
Making Measurements

If your answer is 1.4 cm, try again.



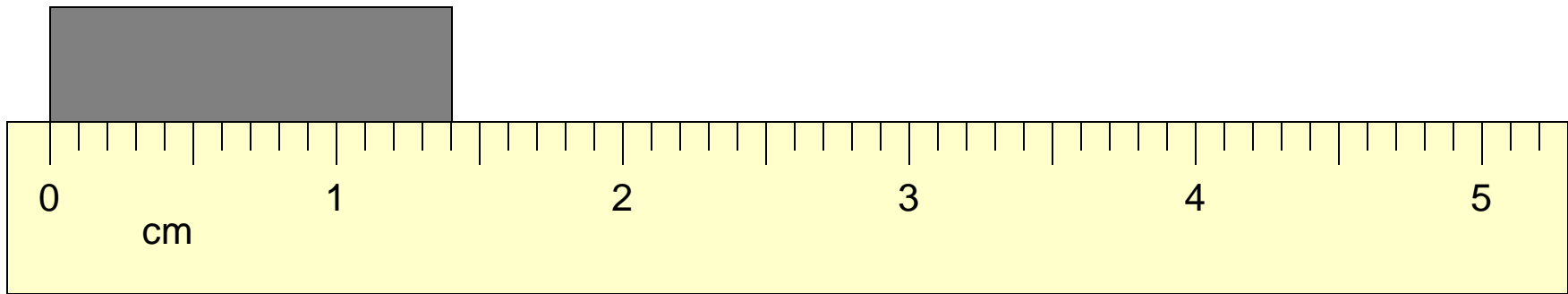
Making Measurements

If you think the edge is just short of the hash mark, then your answer should be “1.39 cm.” If you think the edge is just past the hash mark, then it should be “1.41 cm.” And if the edge appears to be right on the hash mark, then the reading should be “**1.40 cm.**”



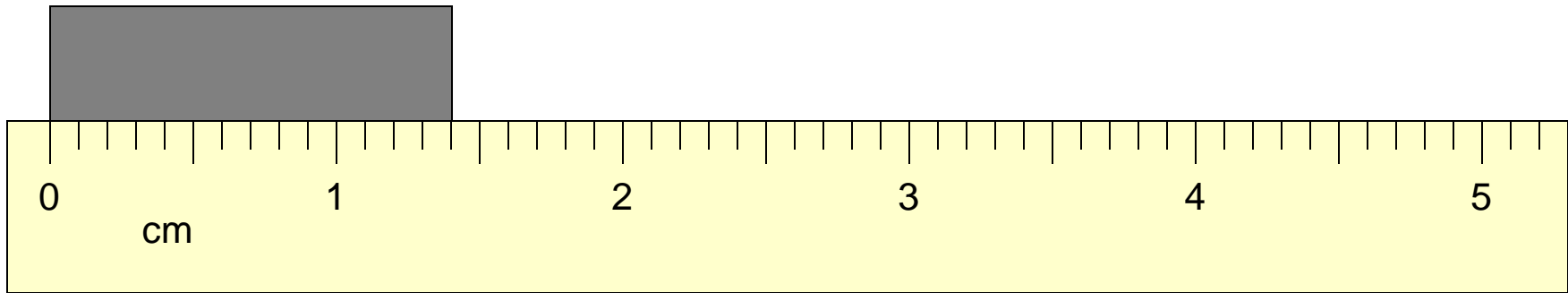
Making Measurements

Don't think that this rectangle is EXACTLY 1.40 cm long. This measurement is no more exact than the previous measurements. The lining up of the edge and the hash mark is still just an approximation.



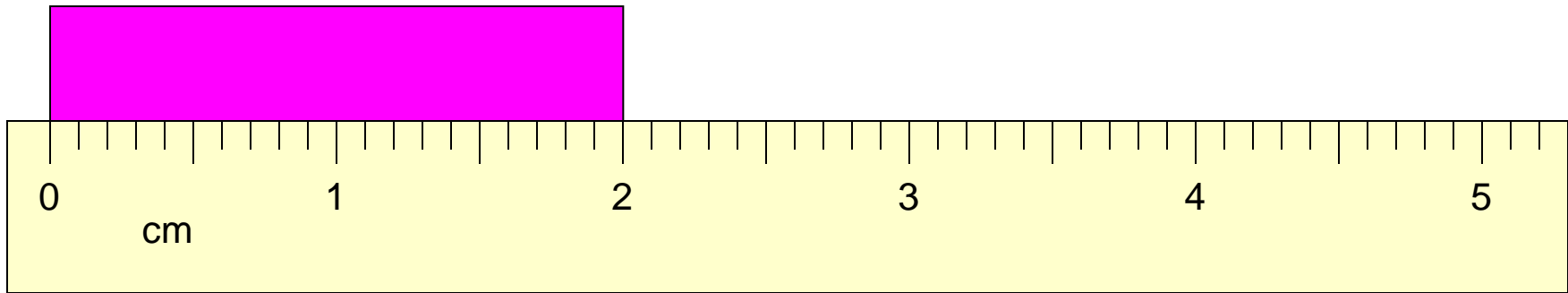
Making Measurements

In fact, there is no such thing as an exact measurement. No object can be exactly 1.40 cm long. That would mean its length is 1.400000000... on forever cm!



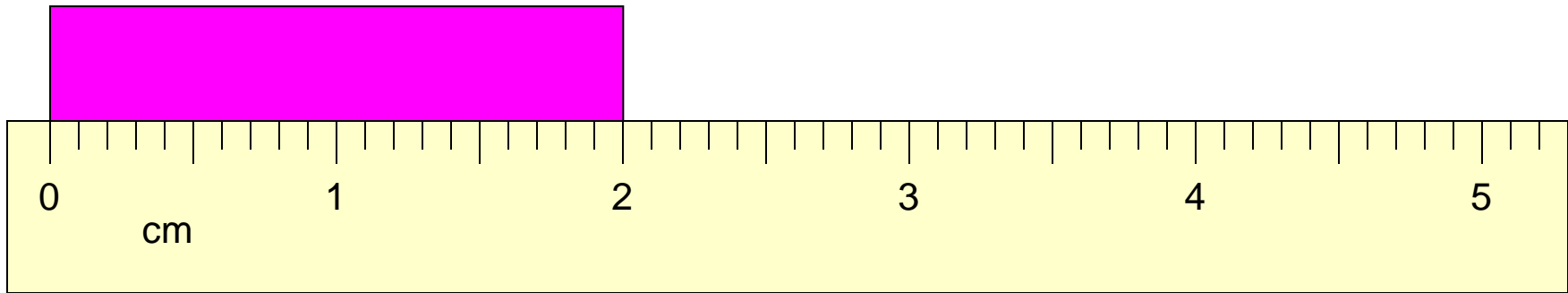
Making Measurements

Let's try another one!



Making Measurements

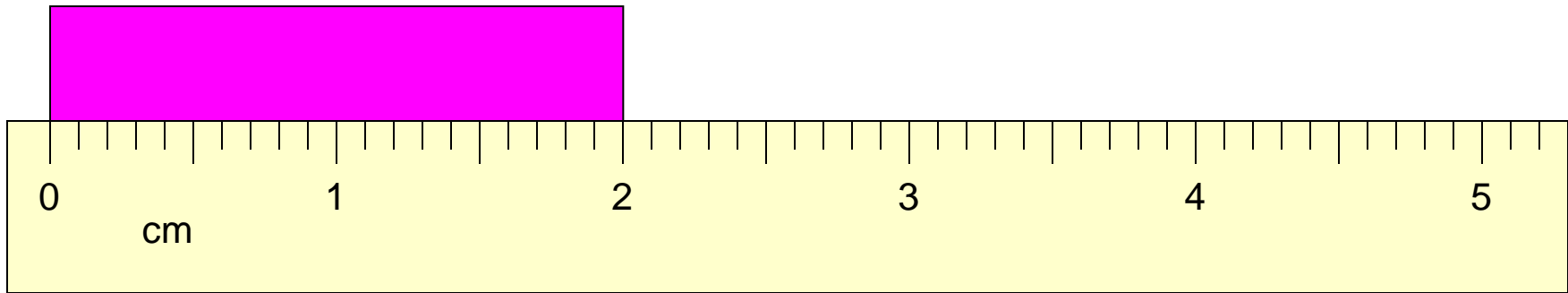
Is your answer “2.00...?”



Making Measurements

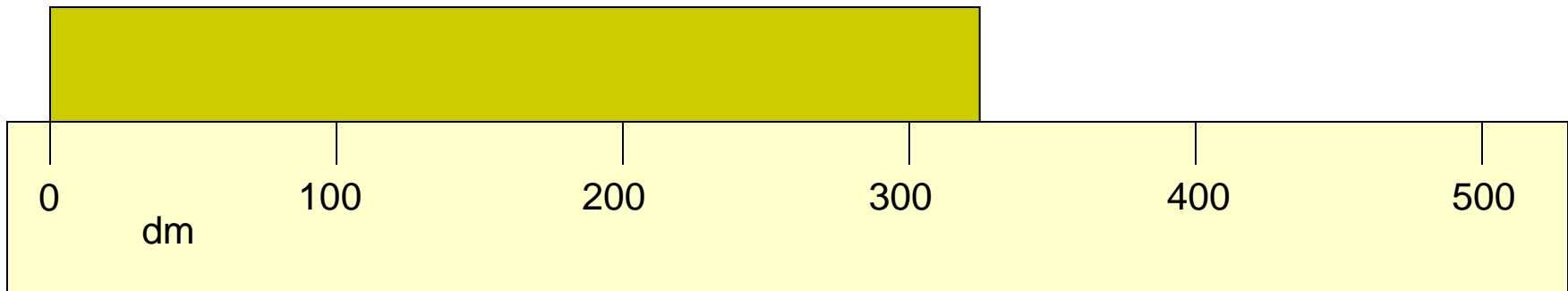
... then you forgot the units!

The correct answer is “2.00 cm.”



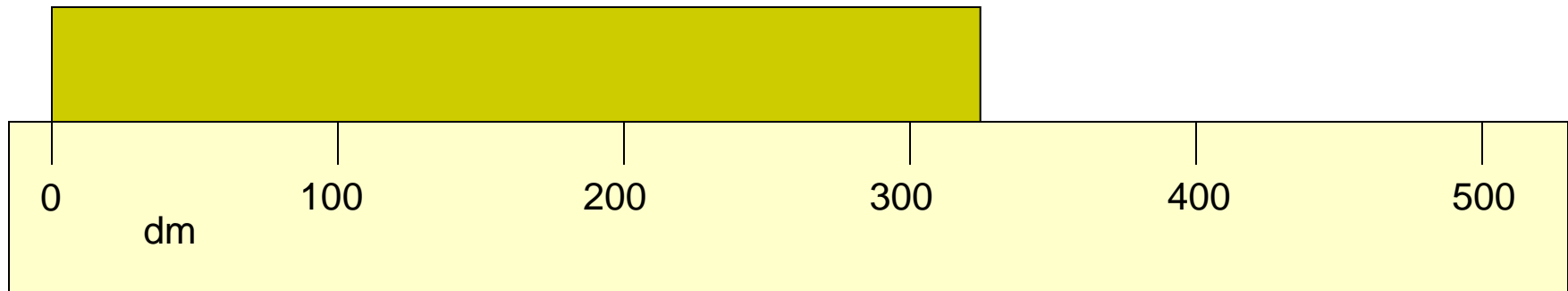
Making Measurements

Now try the measurement below. Careful: the scale is very different. Write down your answer on the scrap paper. (Then continue...)



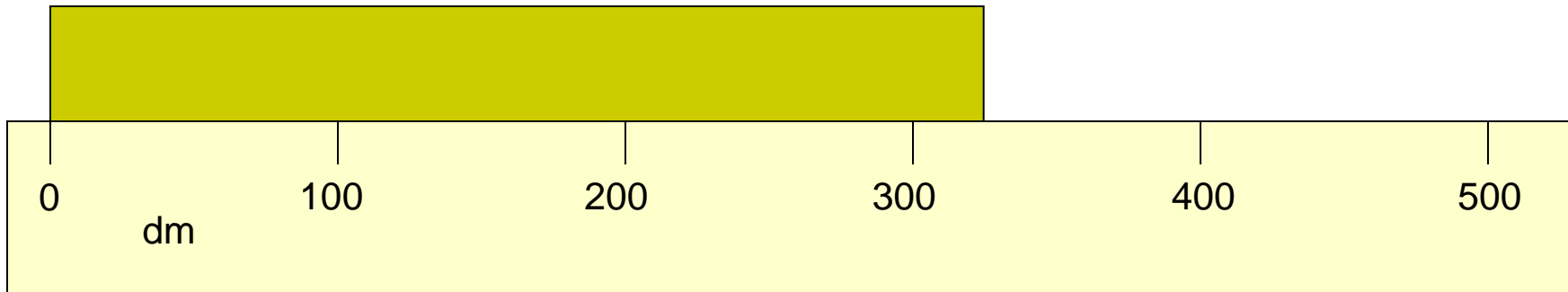
Making Measurements

The answer should be “320 dm” – or “310 dm or “330 dm.” If your answer was “325 dm” because the edge looks like it falls about $\frac{1}{4}$ of the way between the 300 and the 400, then you forgot about the one-guess rule.



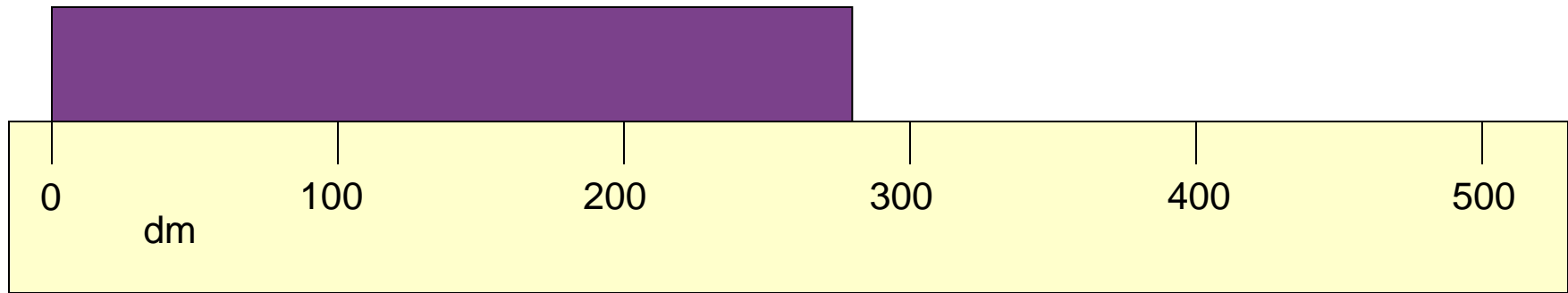
Making Measurements

The measurement is clearly between 300 dm and 400 dm, so it should be 300-something dm. Since we are only allowed one guessed digit, we can say 320 dm, with the “2” being our guess. (By the way, the “0” doesn’t count as a guess. It has to be there as a place holder -- without it, the measurement would be “32 dm” and that doesn’t make sense.)



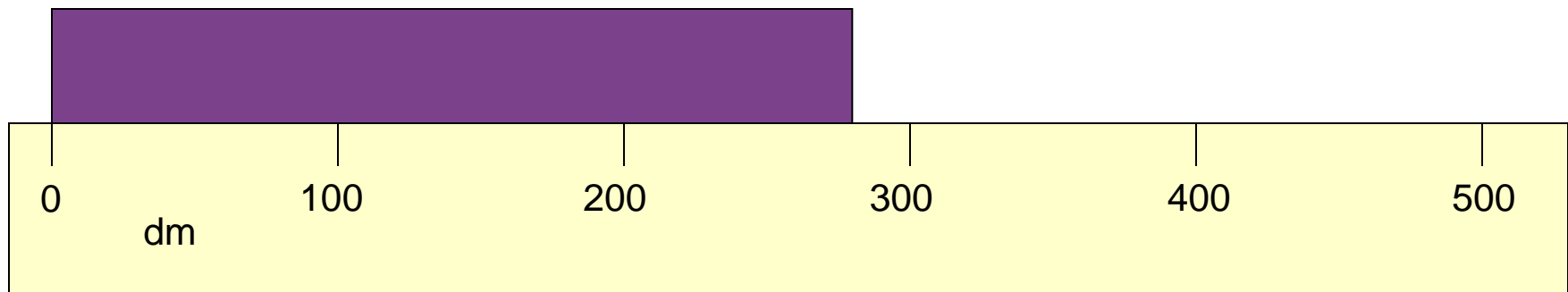
Making Measurements

So now try this one.



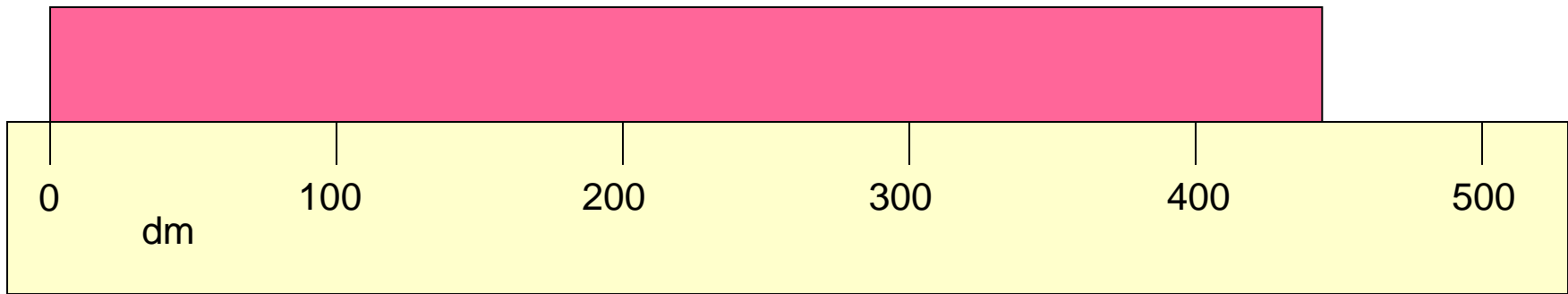
Making Measurements

Did you get “280 dm” (or “270 dm” or “290 dm”)? If so, good job.



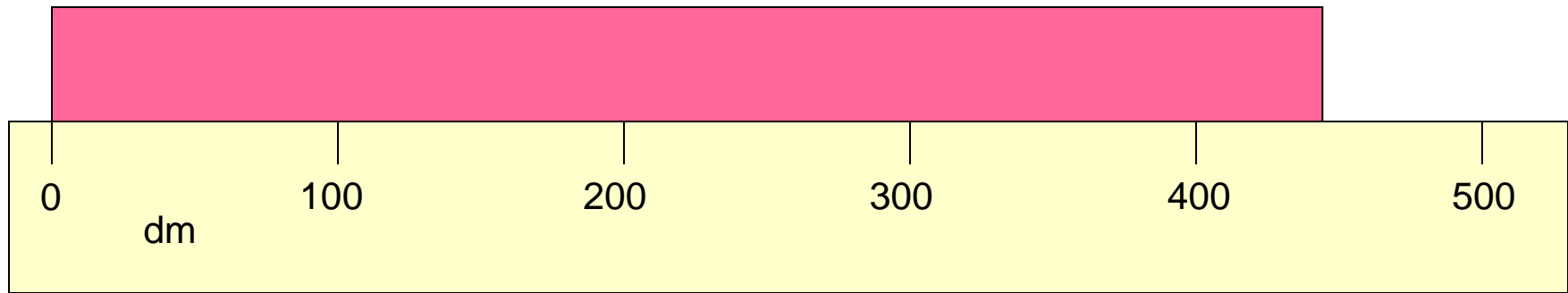
Making Measurements

Now how about this one?



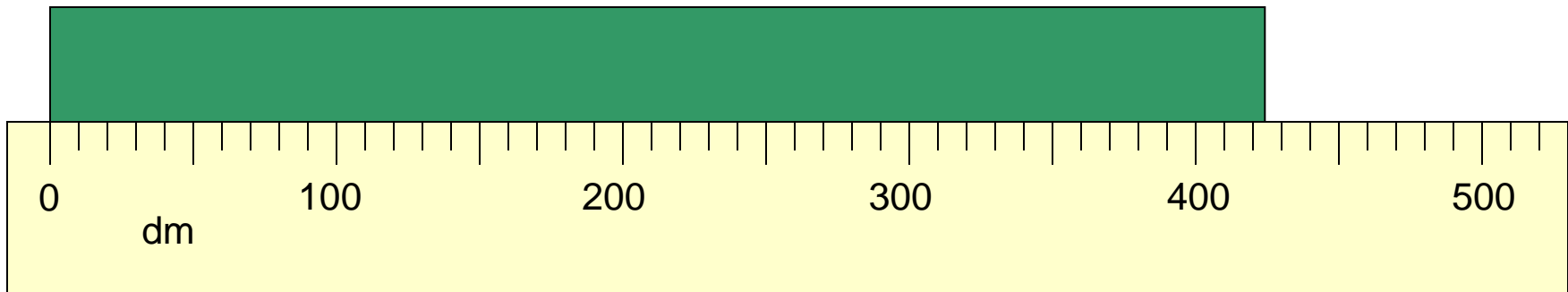
Making Measurements

Was your answer “440 dm” (or “430 dm” or “450 dm”)? If so, you’re right.



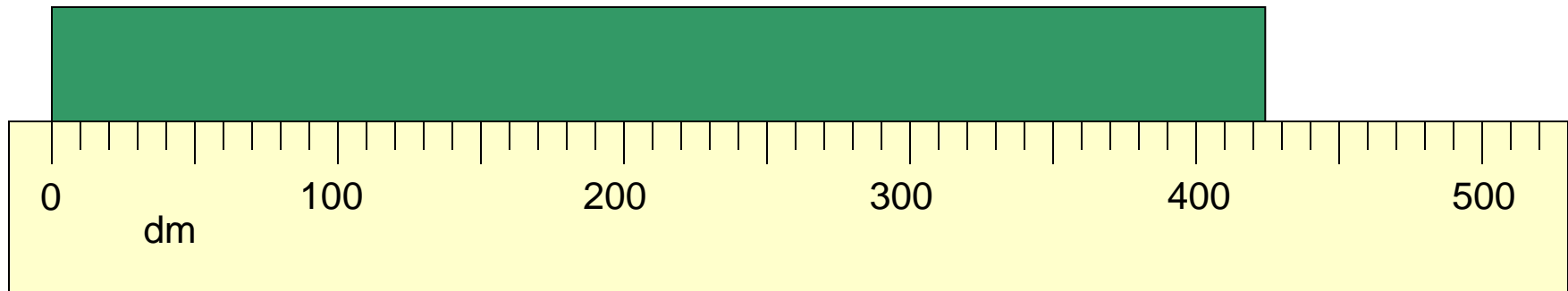
Making Measurements

Now try the measurement below. Again, use scrap paper and then continue.



Making Measurements

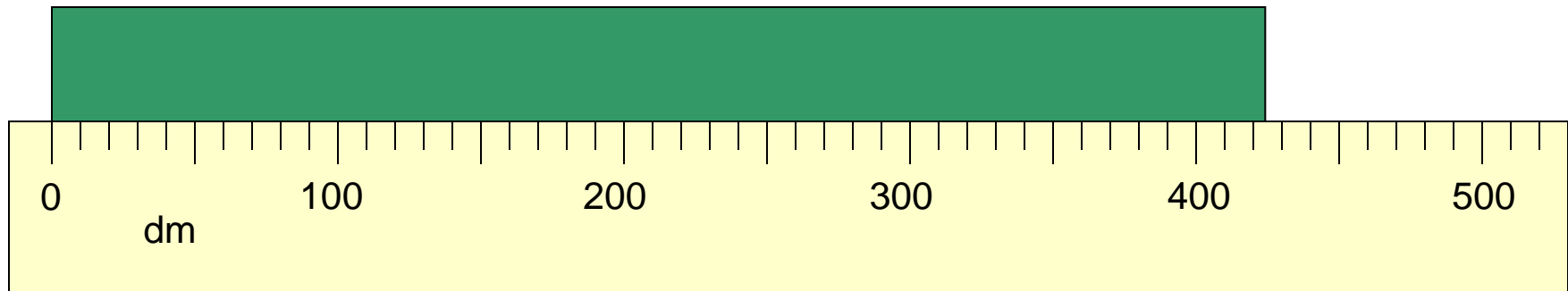
Your answer this time should have been “423 dm”
or perhaps “422 dm” or “424 dm.”



Making Measurements

Your answer this time should have been “423 dm” or perhaps “422 dm” or “424 dm.”

Notice how the scale is incremented to the **tens** place (400, 410, 420...) and so the measurement is made to the **ones** place.



Making Measurements

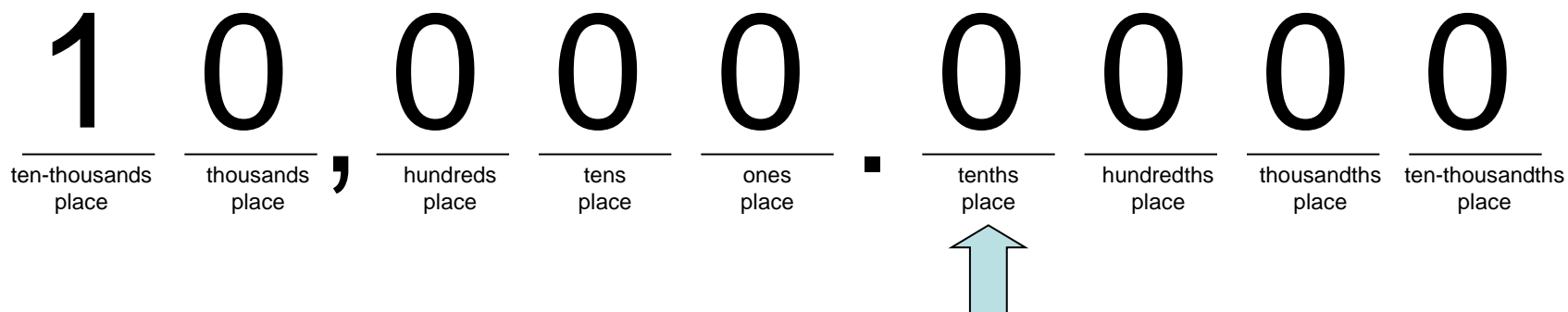
An easy rule to remember is that you should always make a measurement **one place past** what the scale is incremented to.



(Remember way back when you learned the names of the places in a number!)

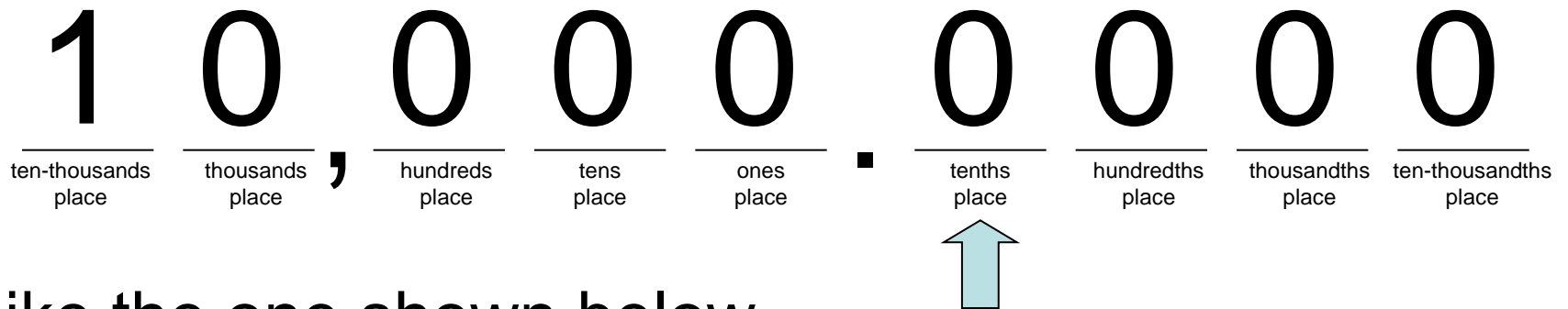
Making Measurements

If a scale is incremented to the tenths place...

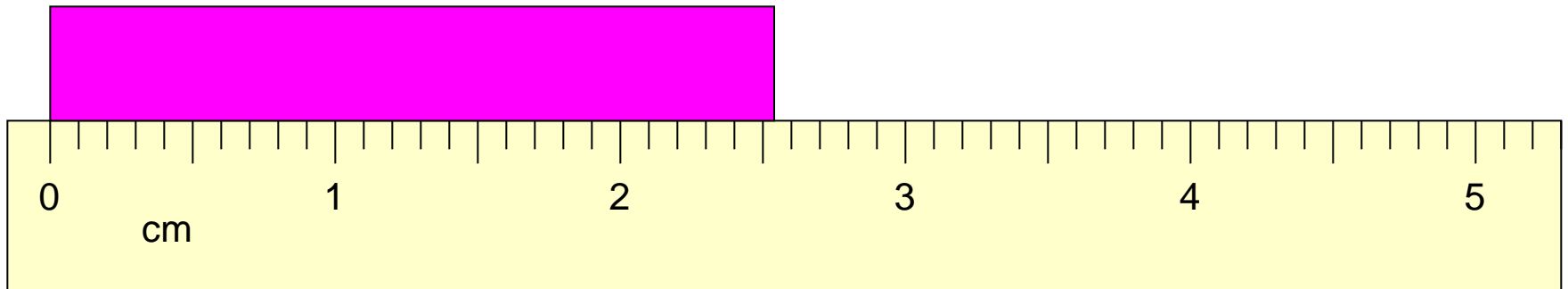


Making Measurements

If a scale is incremented to the tenths place...



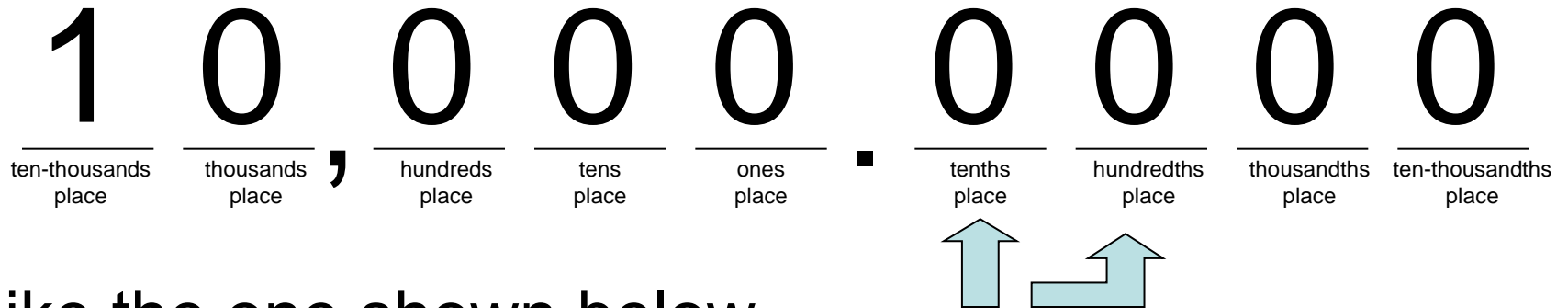
Like the one shown below...



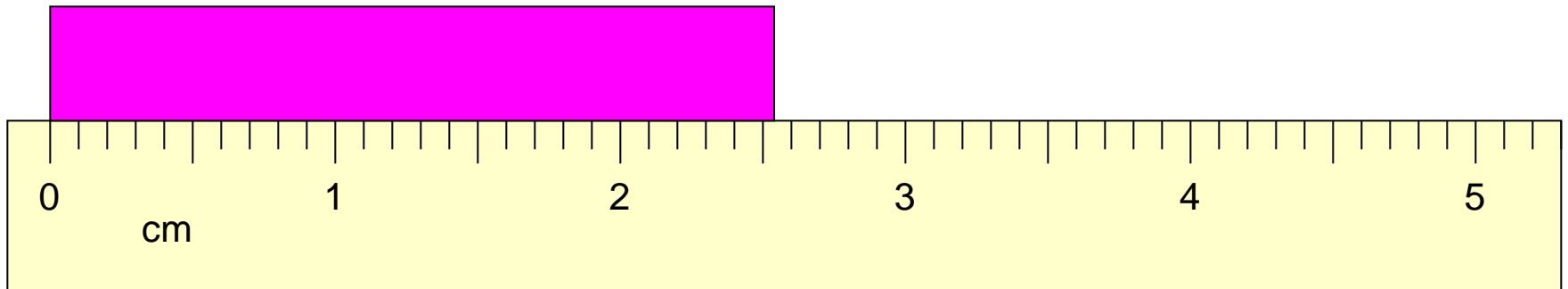
Making Measurements

If a scale is incremented to the tenths place...

It should be read **one place past** -- to the hundredths place



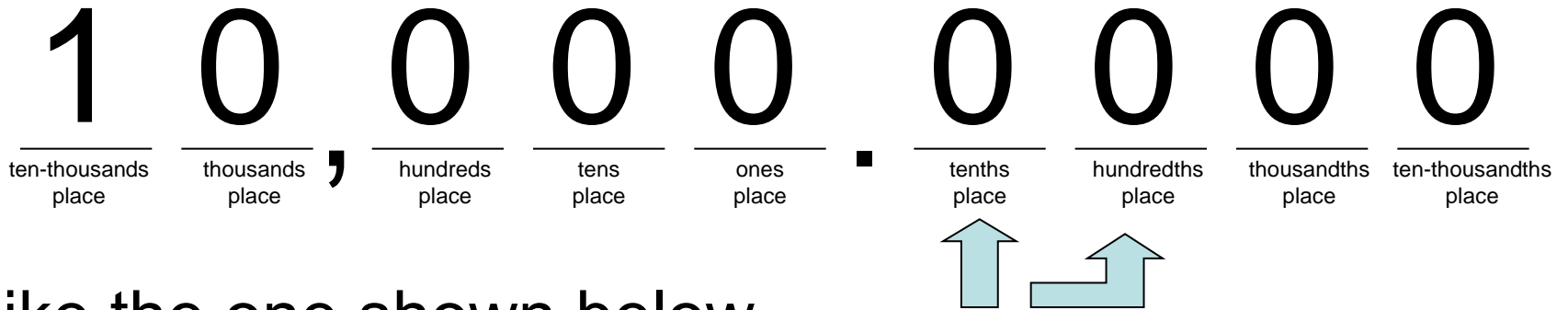
Like the one shown below...



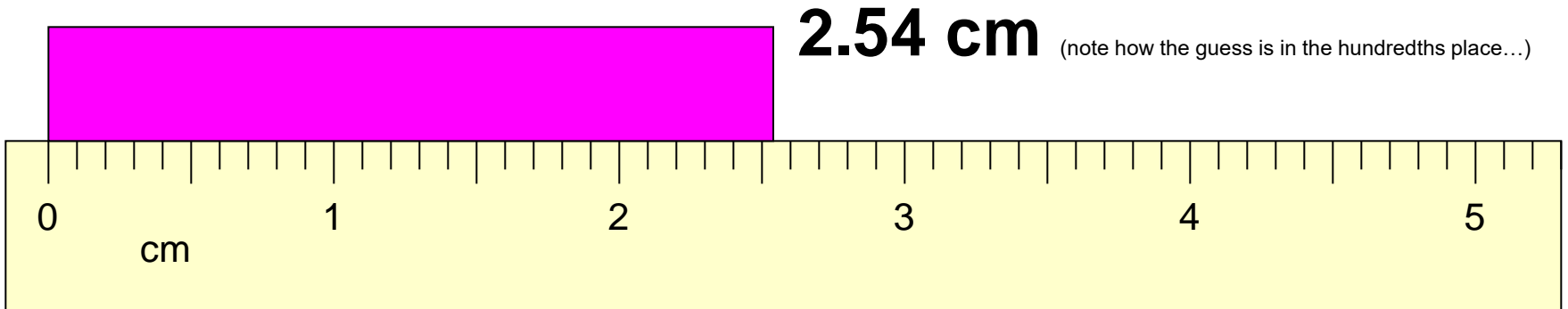
Making Measurements

If a scale is incremented to the tenths place...

It should be read **one place past** -- to the hundredths place

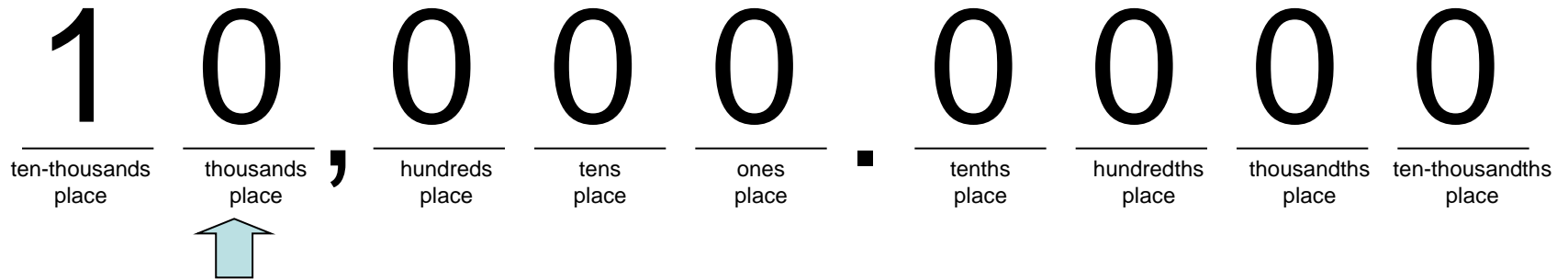


Like the one shown below...



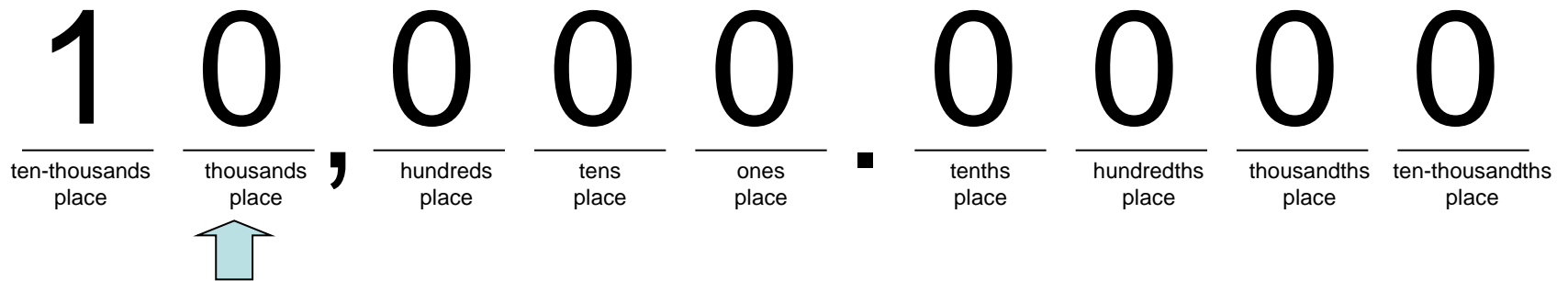
Making Measurements

If a scale is incremented to the thousands place...

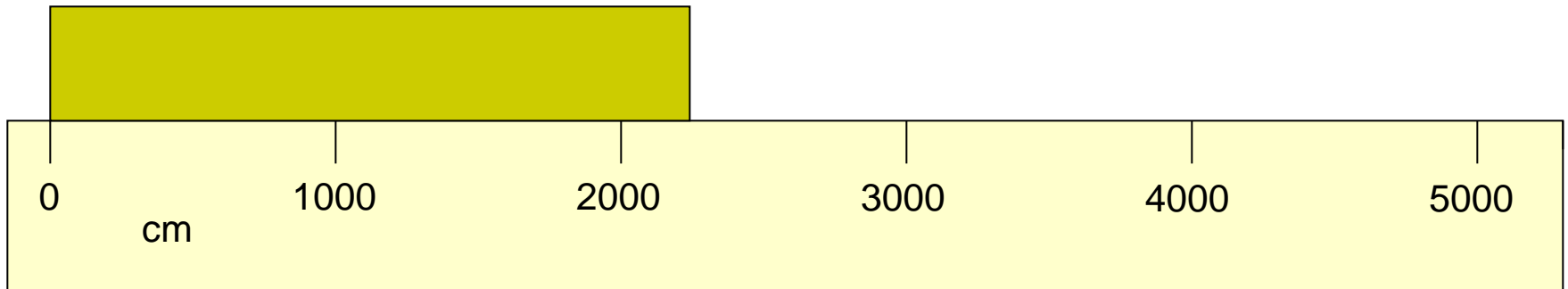


Making Measurements

If a scale is incremented to the thousands place...

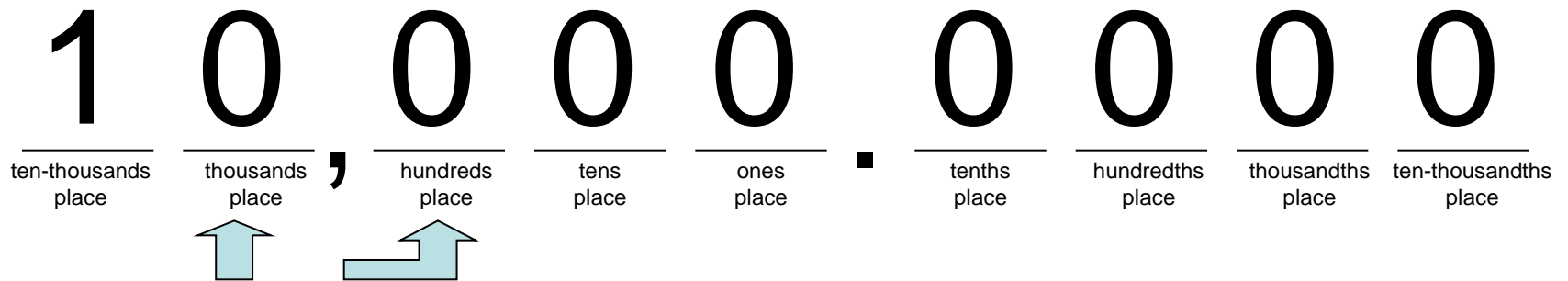


Like the one shown below...

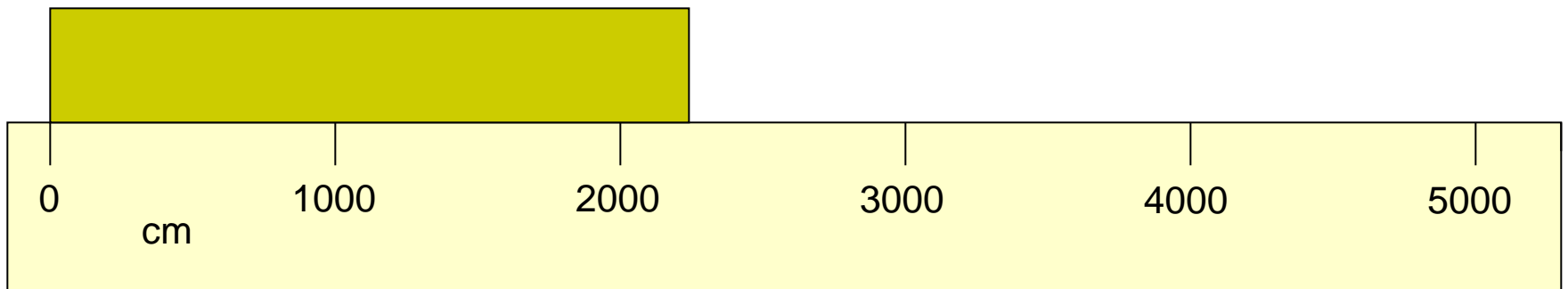


Making Measurements

If a scale is incremented to the thousands place...
It should be read **one place past** – to the
hundreds place.

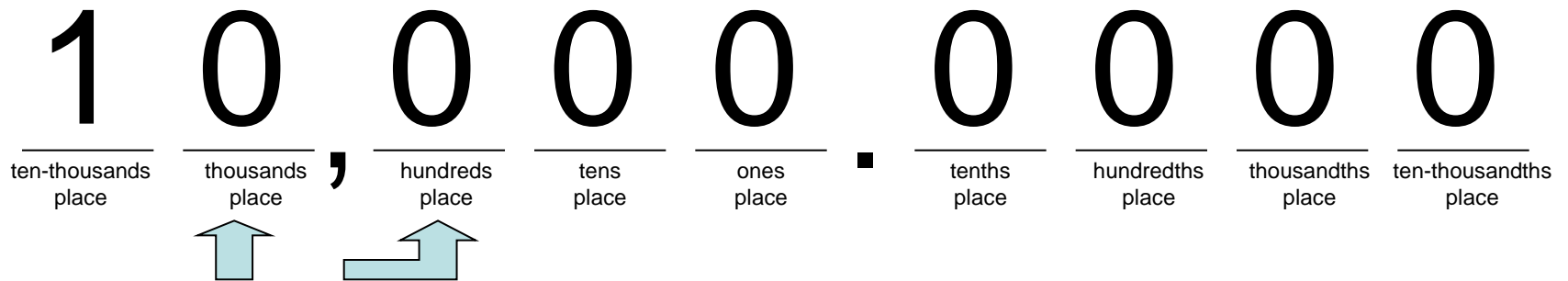


Like the one shown below...



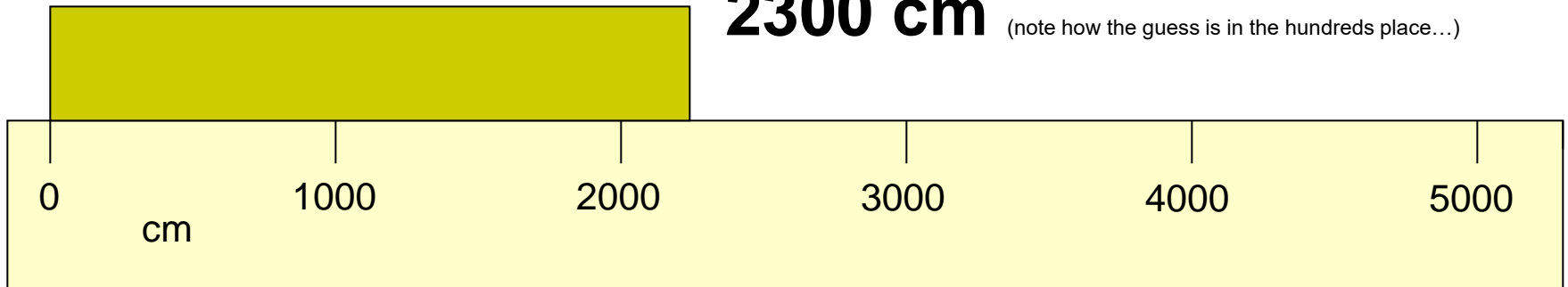
Making Measurements

If a scale is incremented to the thousands place...
It should be read **one place past** – to the
hundreds place.



Like the one shown below...

2300 cm (note how the guess is in the hundreds place...)



Making Measurements

For the next several practice problems, write your answers on the scrap paper, then compare it to the answer given. If your answer is the same – or only off in the last digit (plus or minus 1), then consider it a good answer. If not, look at it carefully to see why it was wrong.

Making Measurements

For the next several practice problems, write your answers on the scrap paper, then compare it to the answer given. If your answer is the same – or only off in the last digit (plus or minus 1), then consider it a good answer. If not, look at it carefully to see why it was wrong. And by the way...

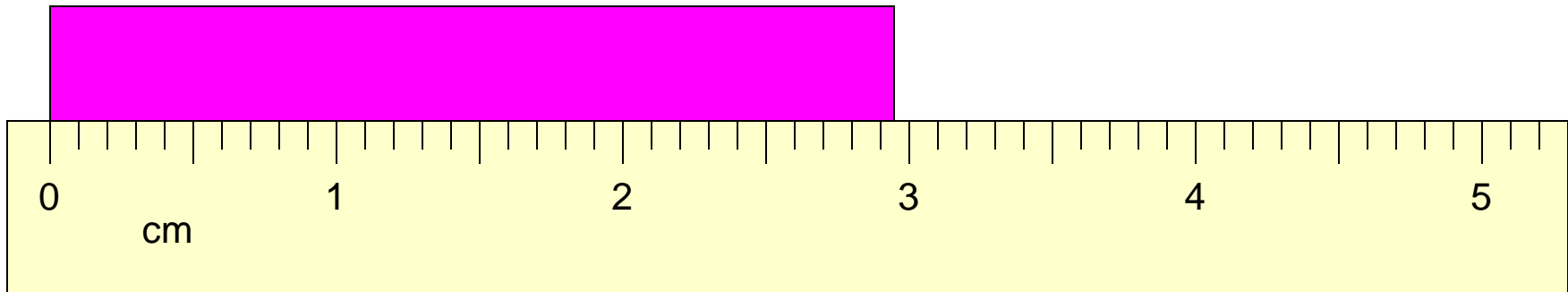
Making Measurements

For the next several practice problems, write your answers on the scrap paper, then compare it to the answer given. If your answer is the same – or only off in the last digit (plus or minus 1), then consider it a good answer. If not, look at it carefully to see why it was wrong. And by the way...

DON'T FORGET THE UNITS!

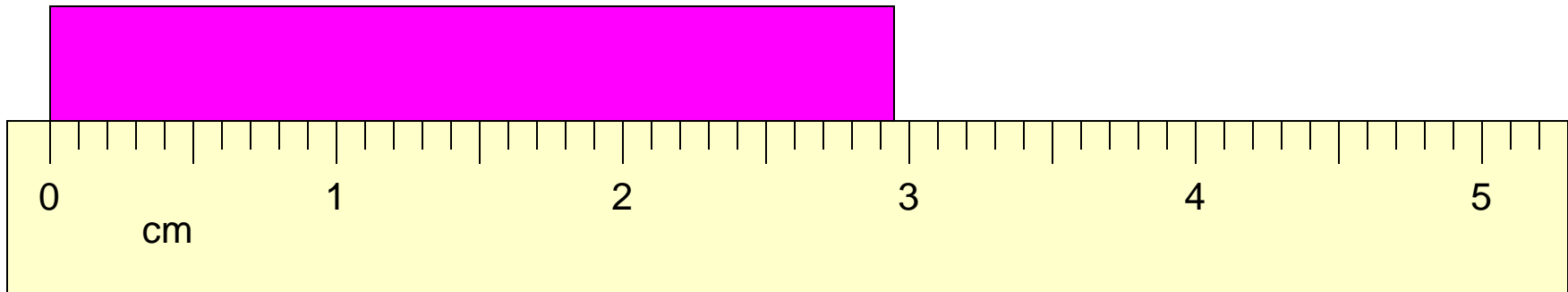
Making Measurements

#1



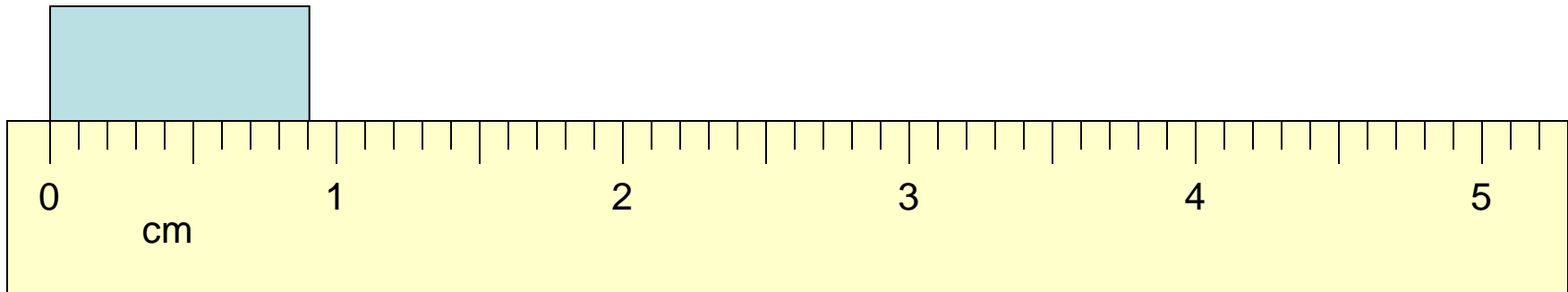
Making Measurements

#1 2.94 cm



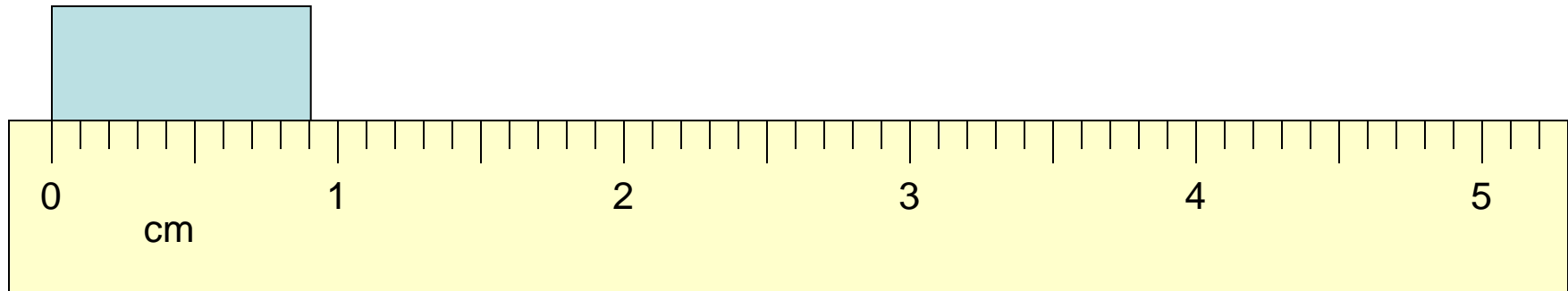
Making Measurements

#2



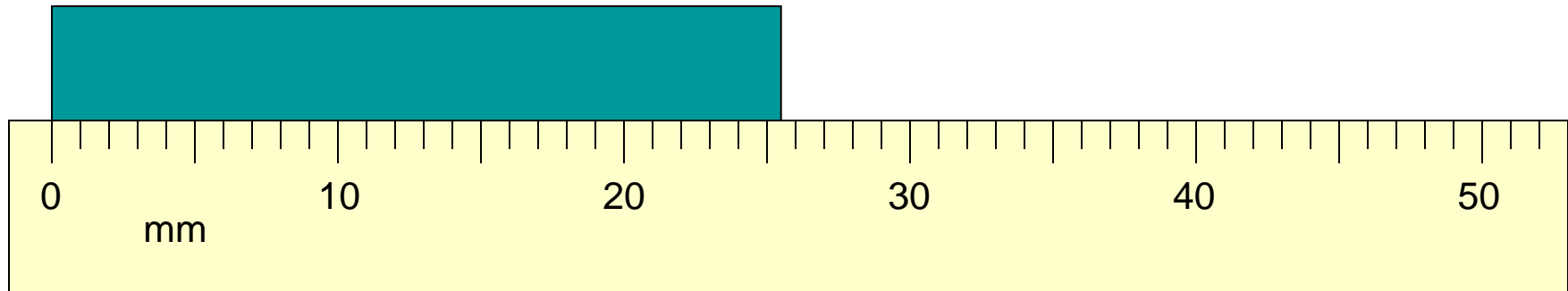
Making Measurements

#2 0.90 cm



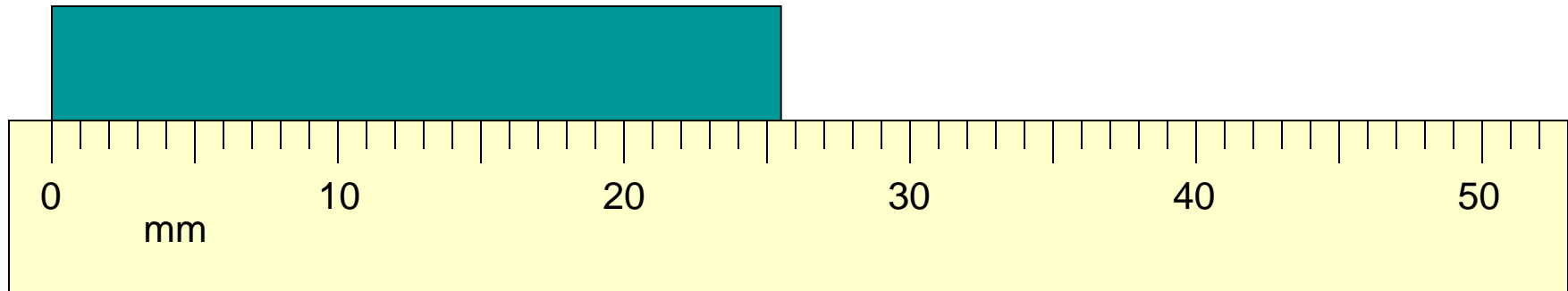
Making Measurements

#3



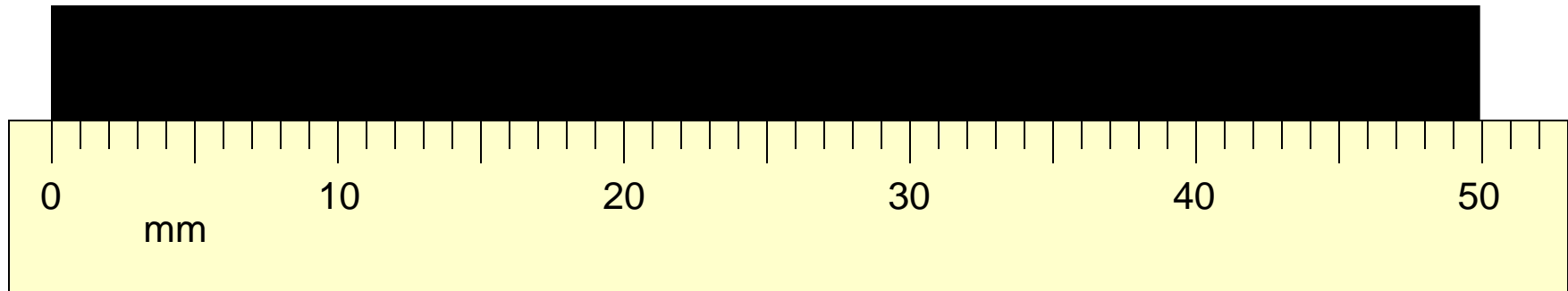
Making Measurements

#3 25.3 mm



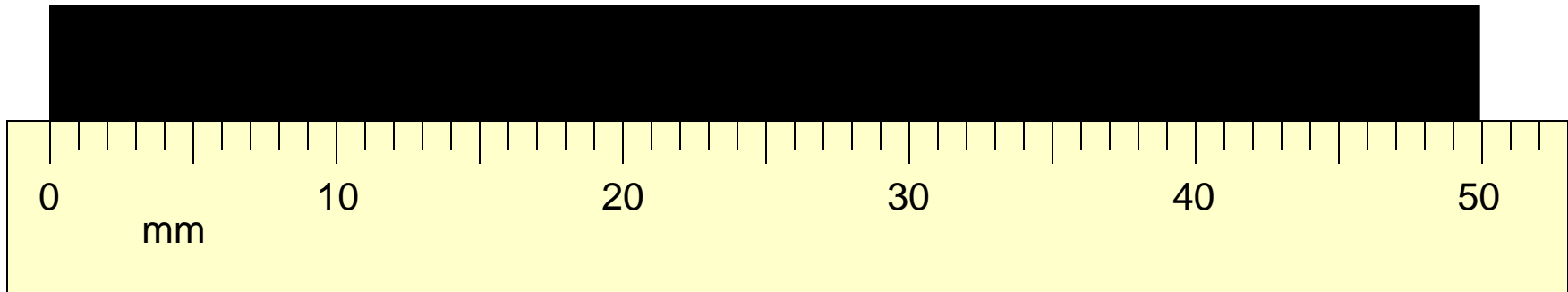
Making Measurements

#4



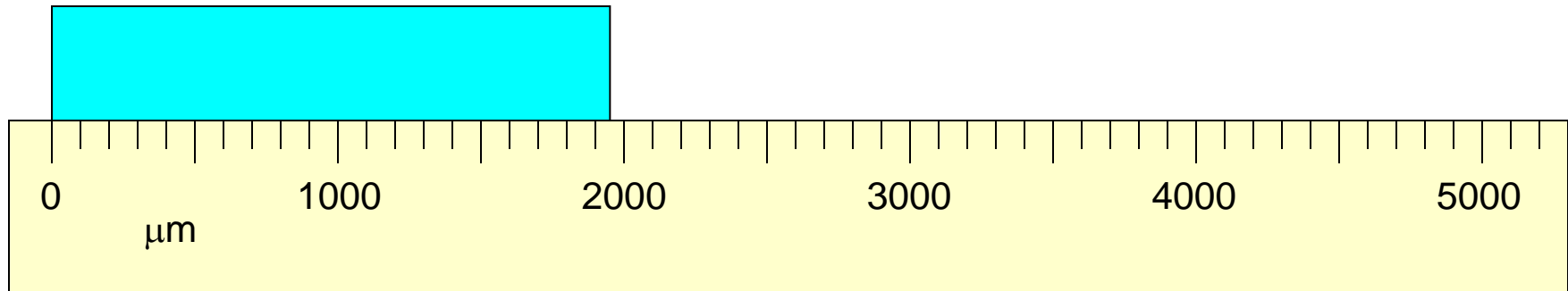
Making Measurements

#4 49.9 mm



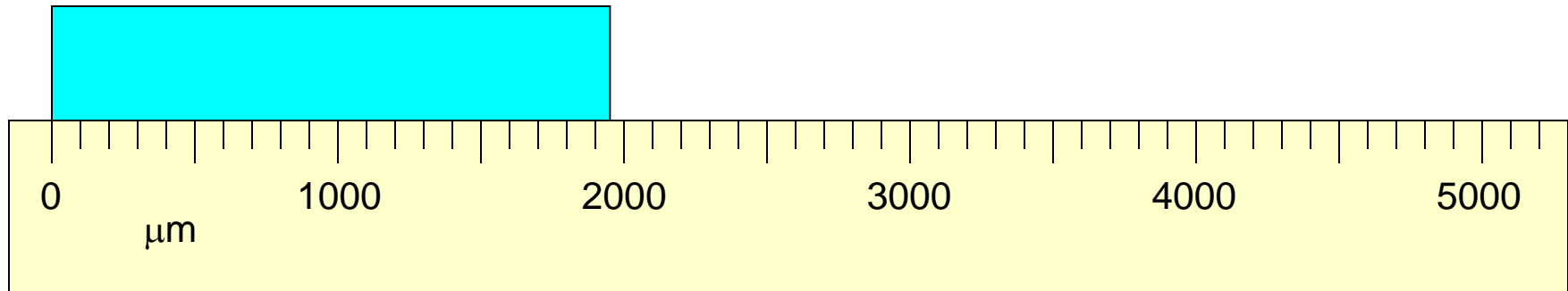
Making Measurements

#5



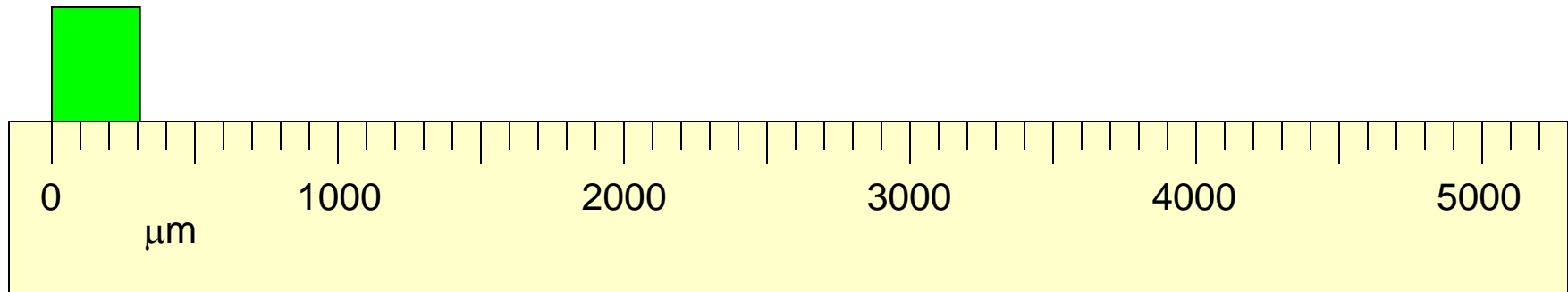
Making Measurements

#5 1950 μm



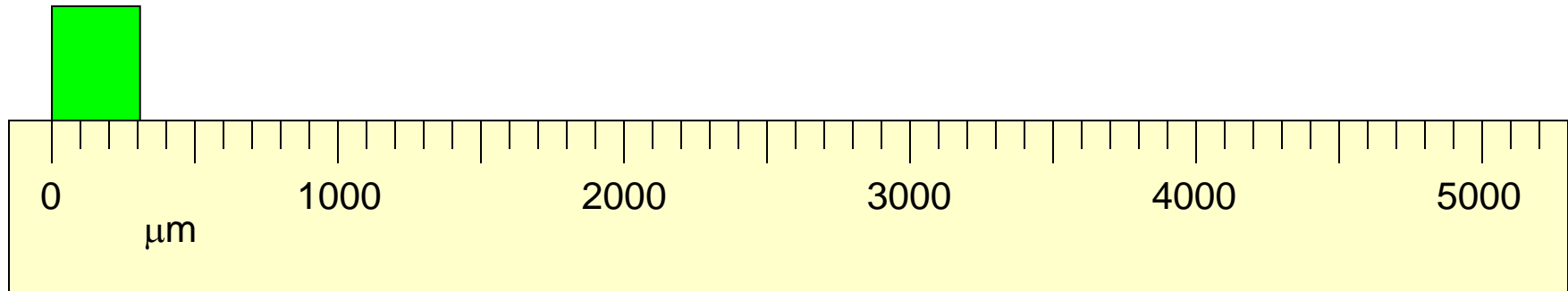
Making Measurements

#6



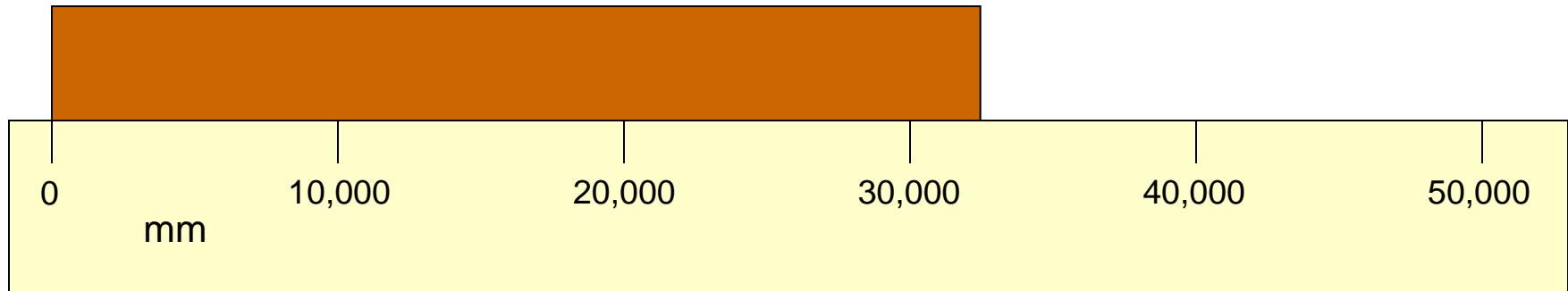
Making Measurements

#6 310 μm



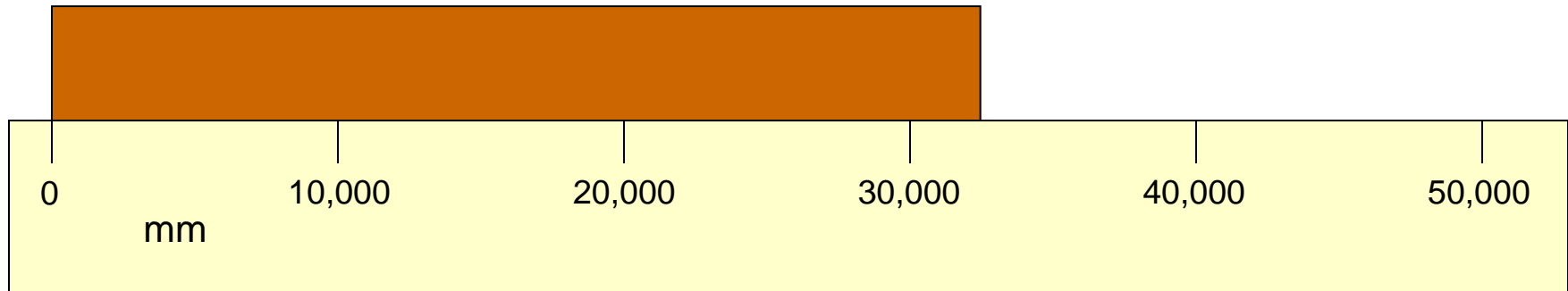
Making Measurements

#7



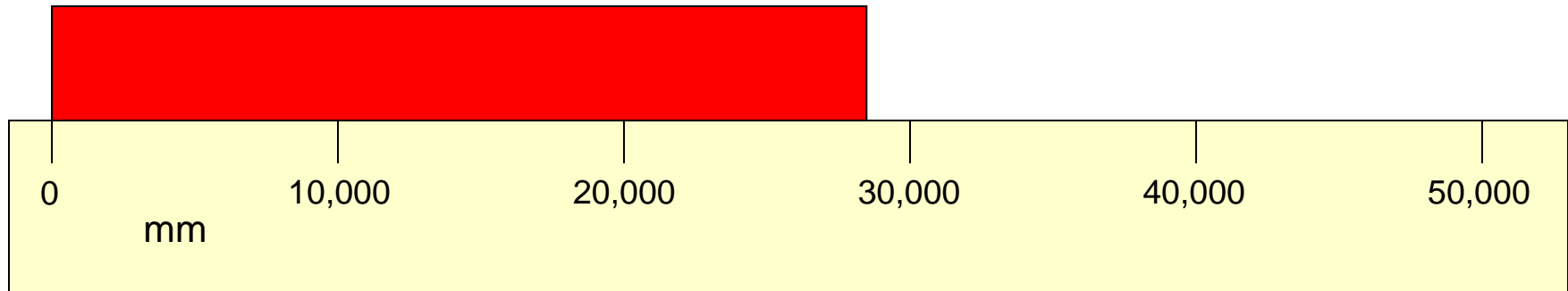
Making Measurements

#7 32,000 mm



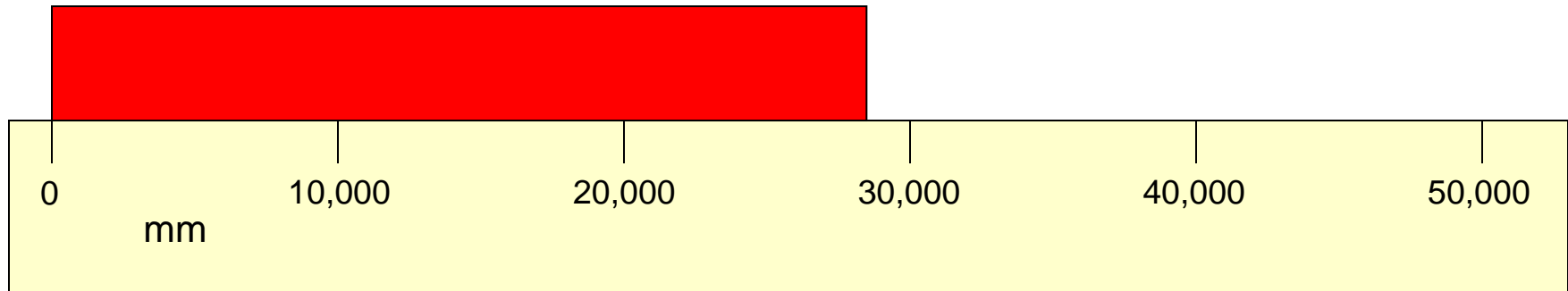
Making Measurements

#8



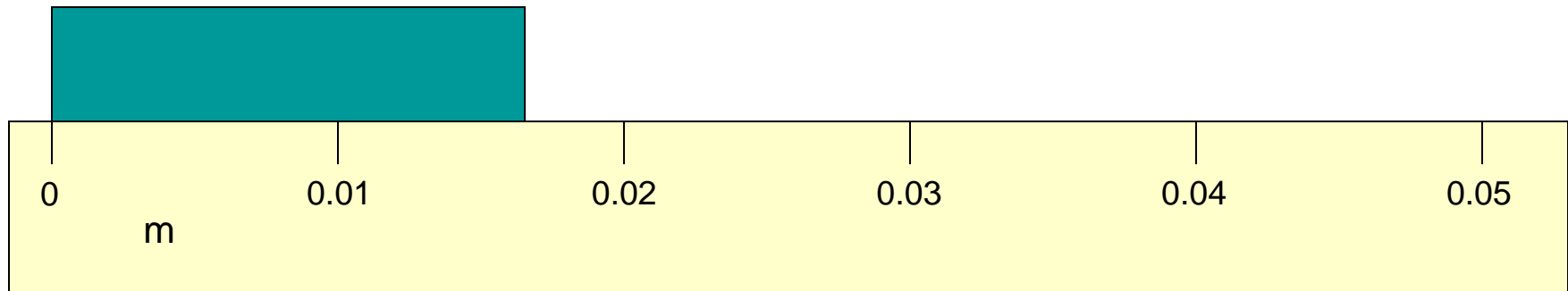
Making Measurements

#8 28,000 mm



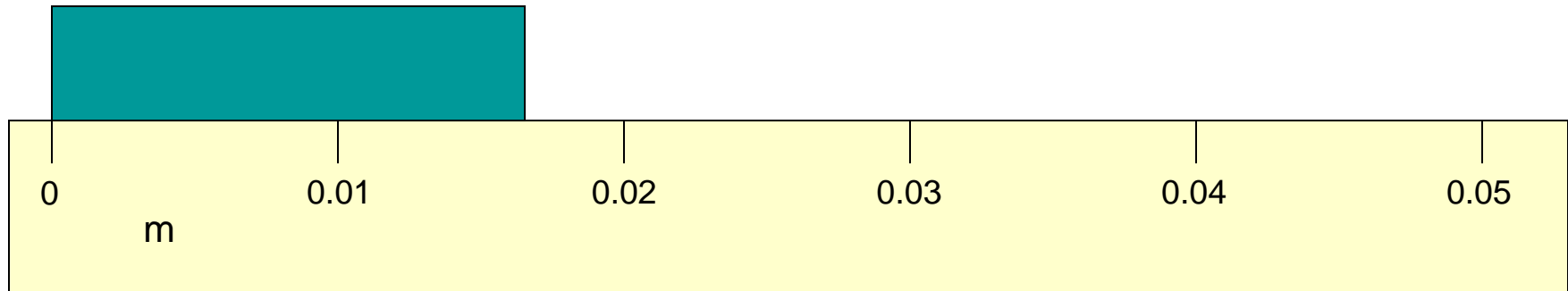
Making Measurements

#9



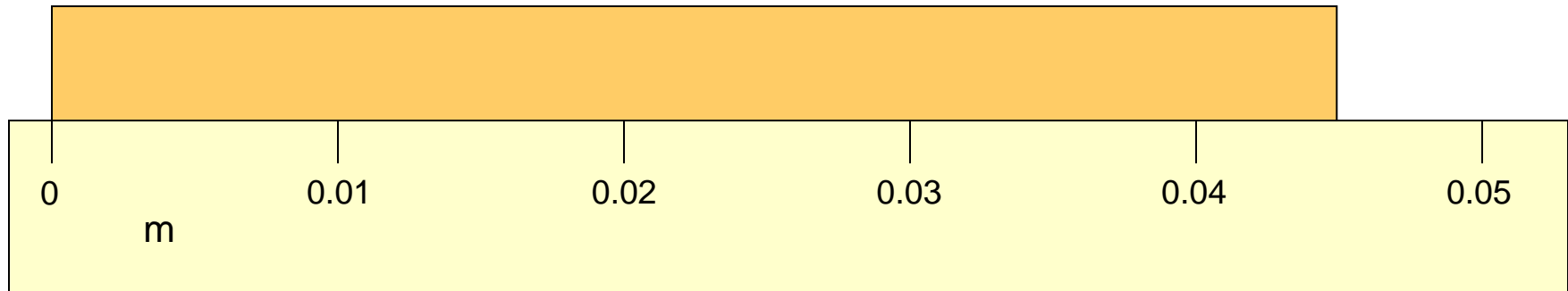
Making Measurements

#9 0.017 m



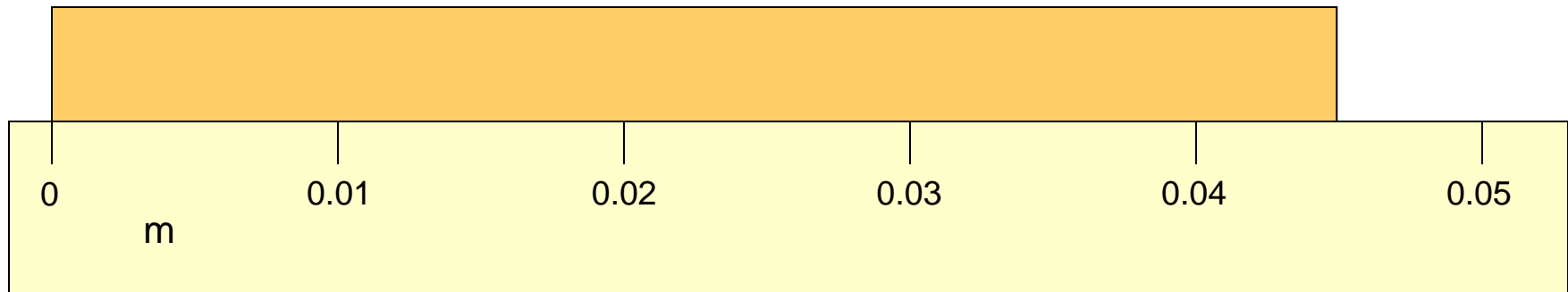
Making Measurements

#10



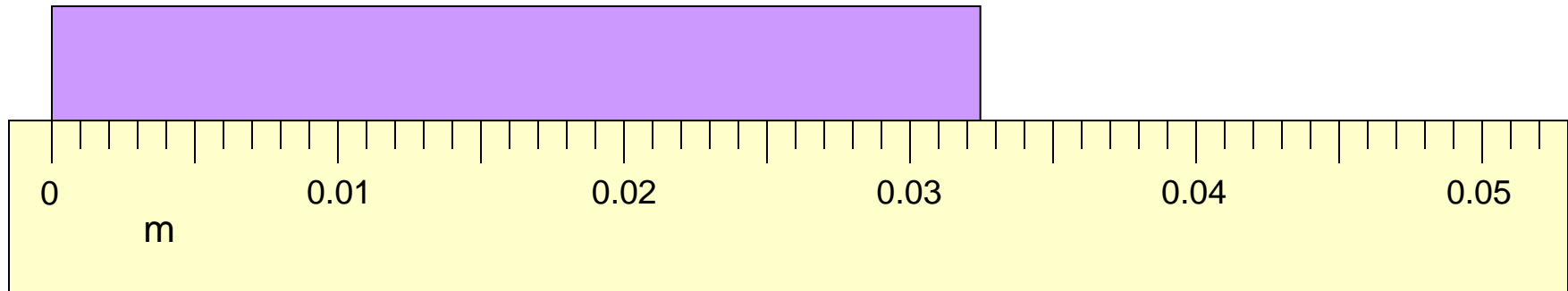
Making Measurements

#10 0.045 m



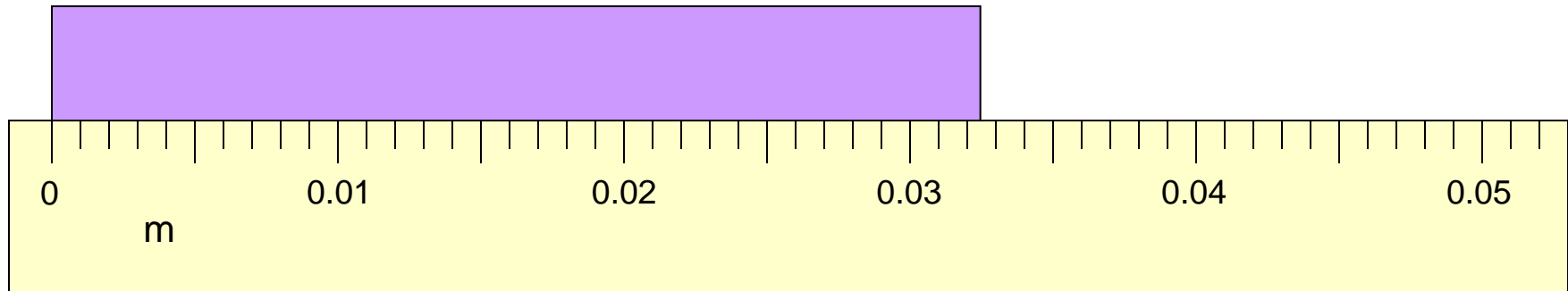
Making Measurements

#11



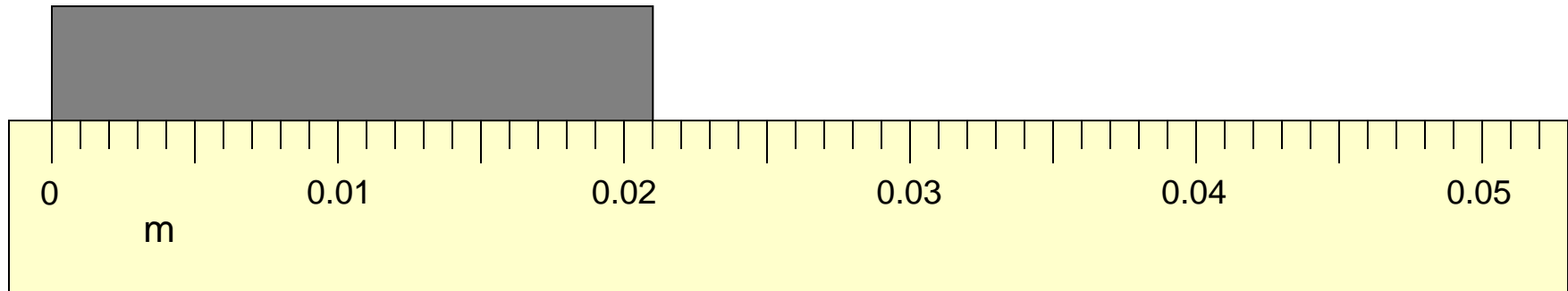
Making Measurements

#11 0.0324 m



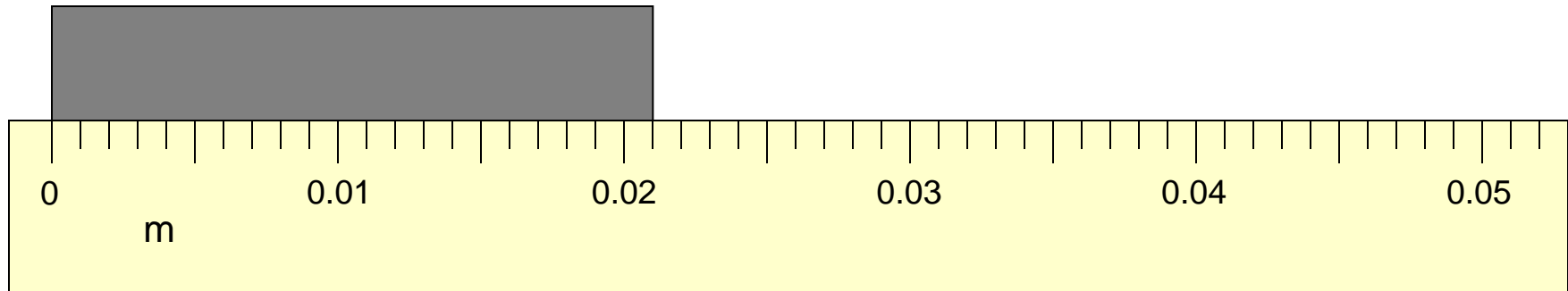
Making Measurements

#12



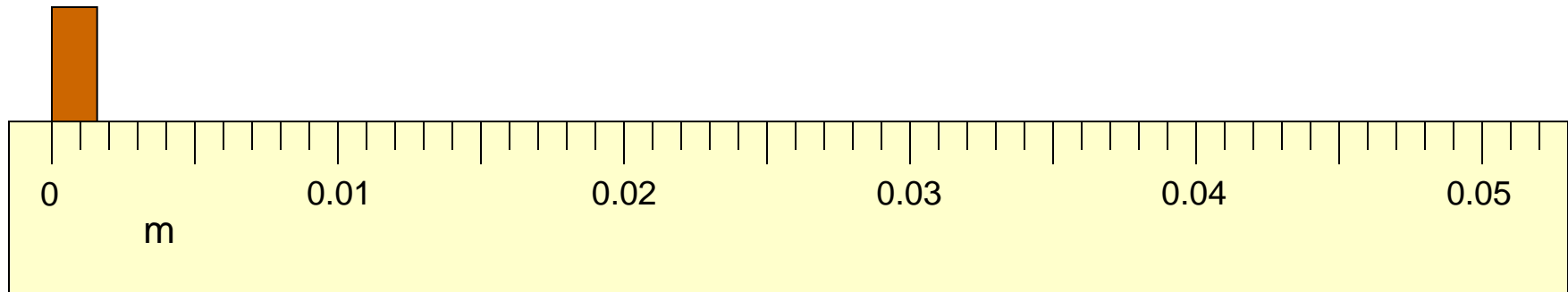
Making Measurements

#12 0.0210 m



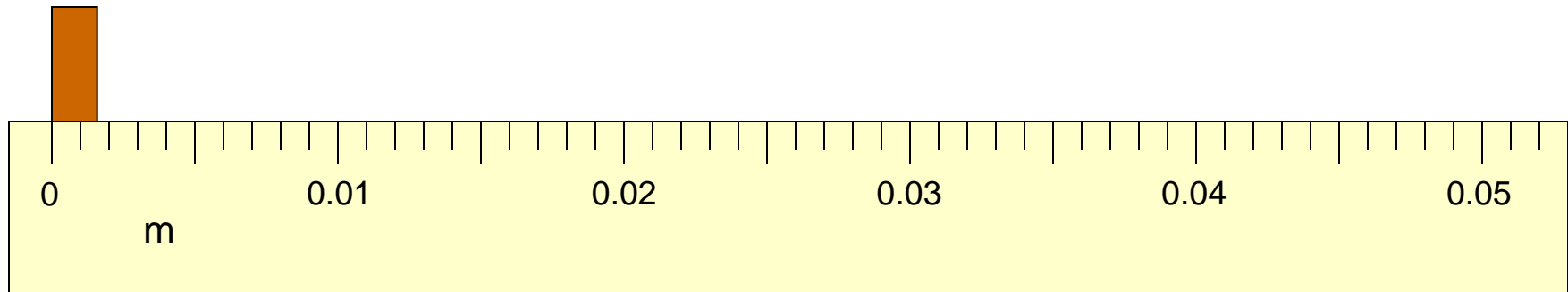
Making Measurements

#13



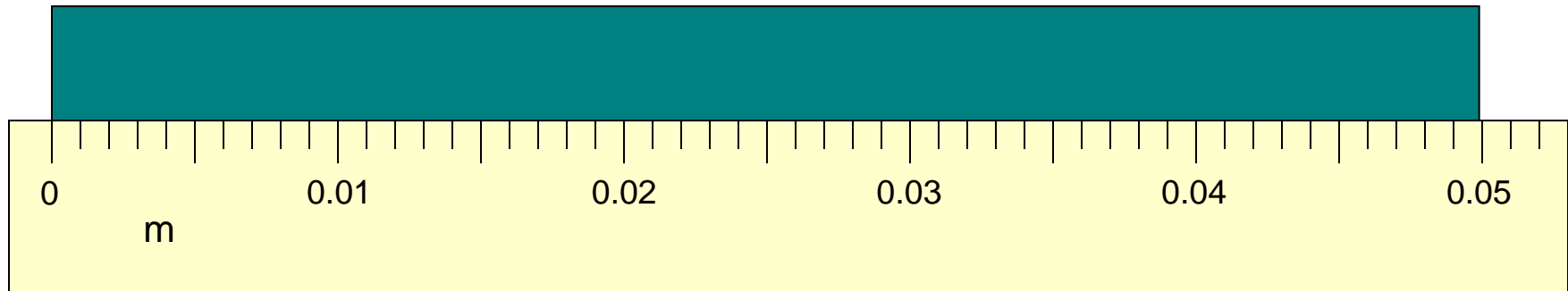
Making Measurements

#13 0.0016 m



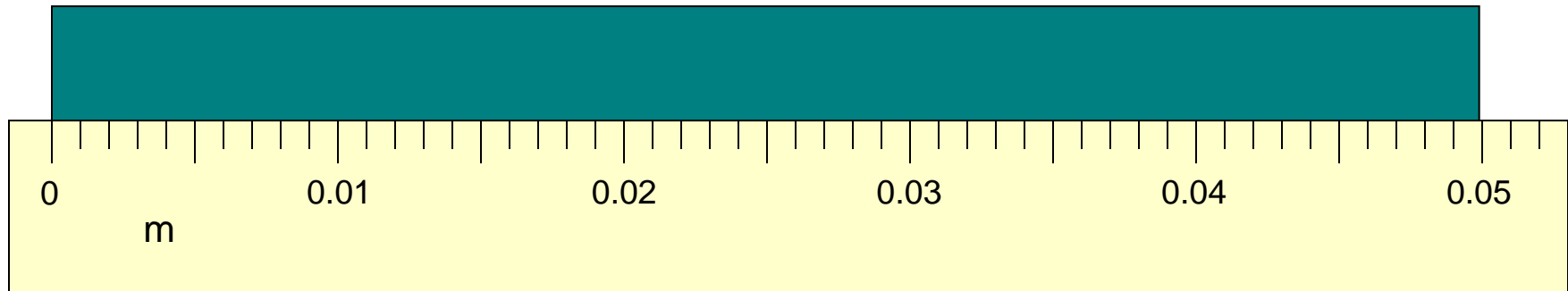
Making Measurements

#14



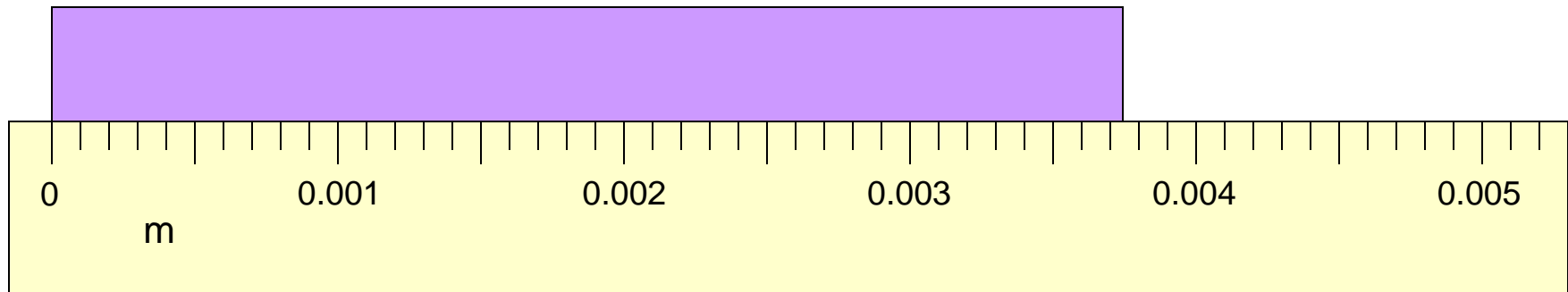
Making Measurements

#14 0.0498 m



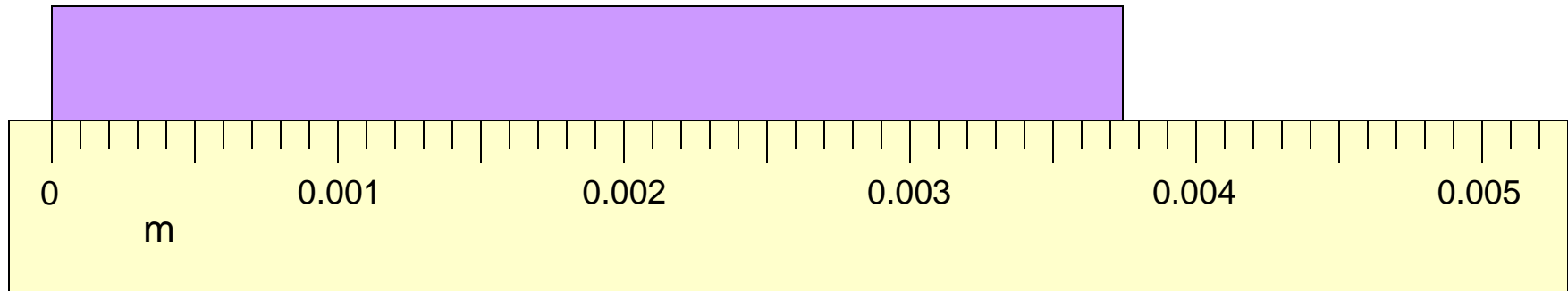
Making Measurements

#15



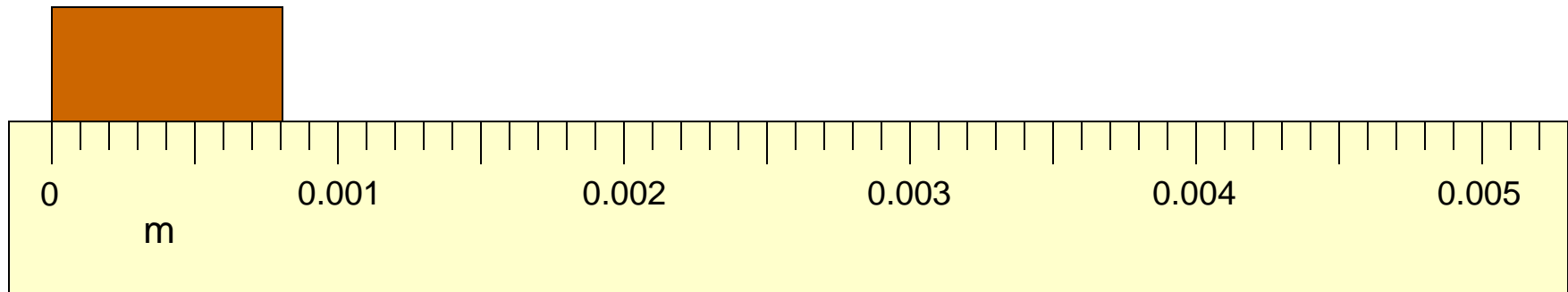
Making Measurements

#15 0.00374 m



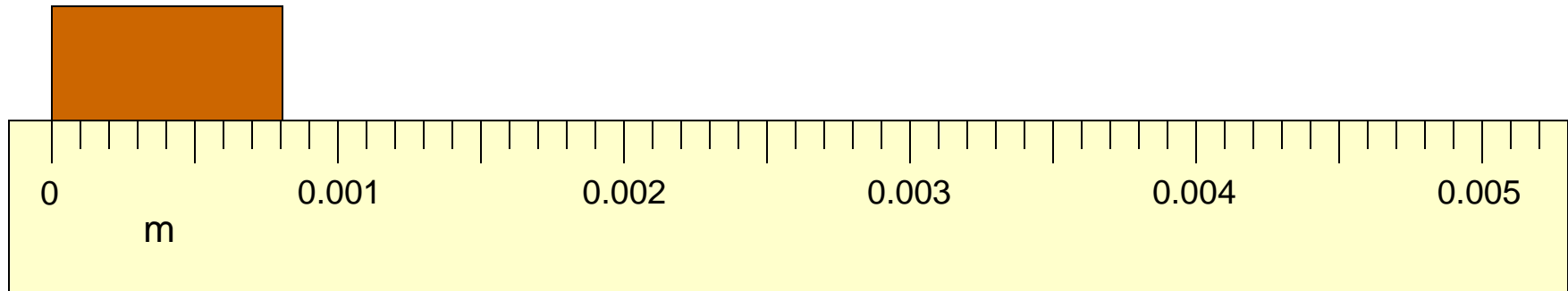
Making Measurements

#16



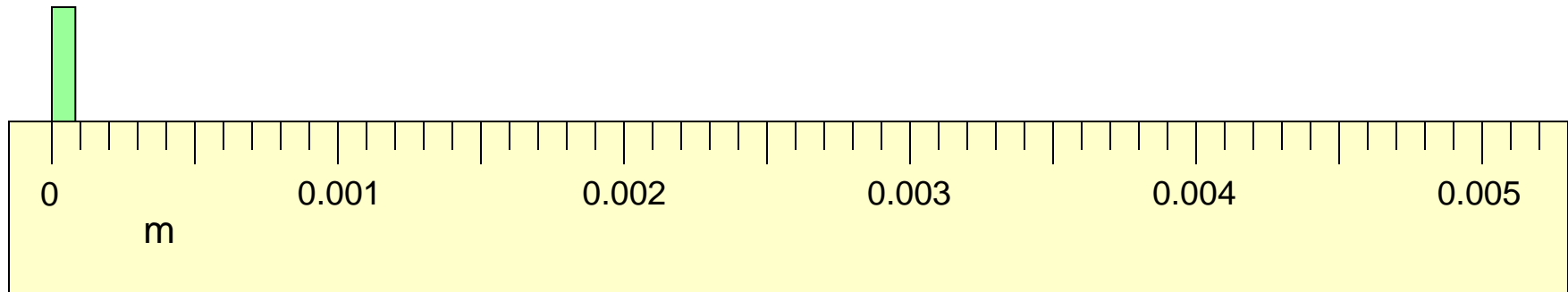
Making Measurements

#16 0.00080 m



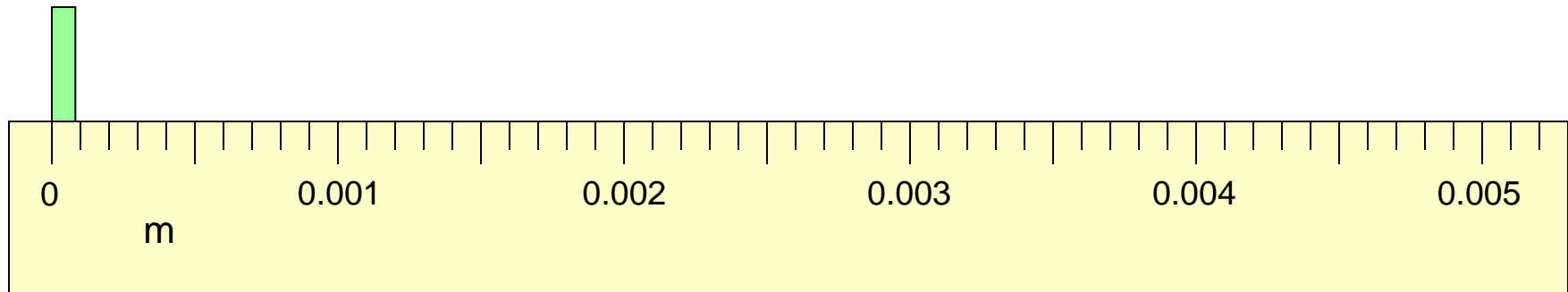
Making Measurements

#17



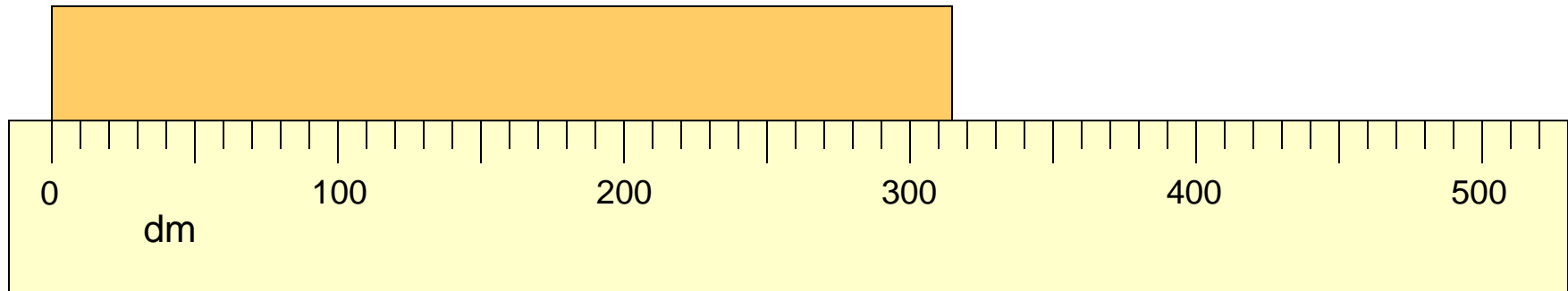
Making Measurements

#17 0.00008 m



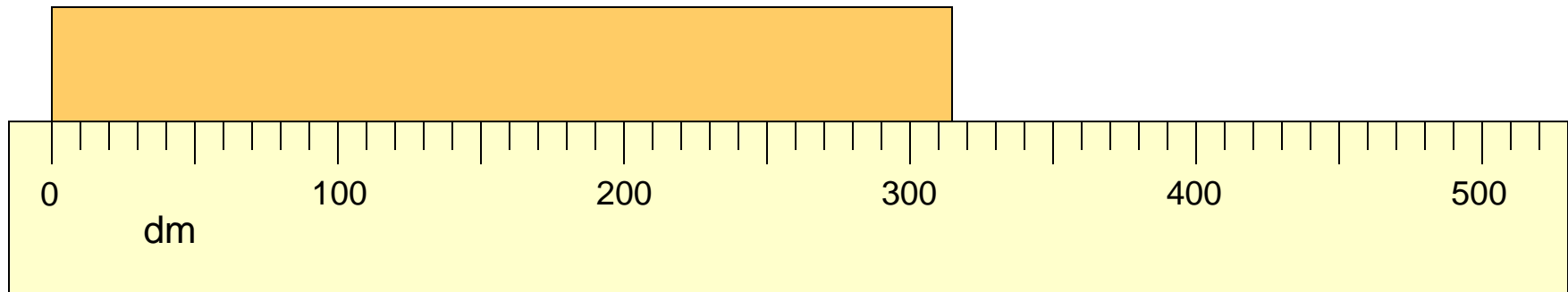
Making Measurements

#18



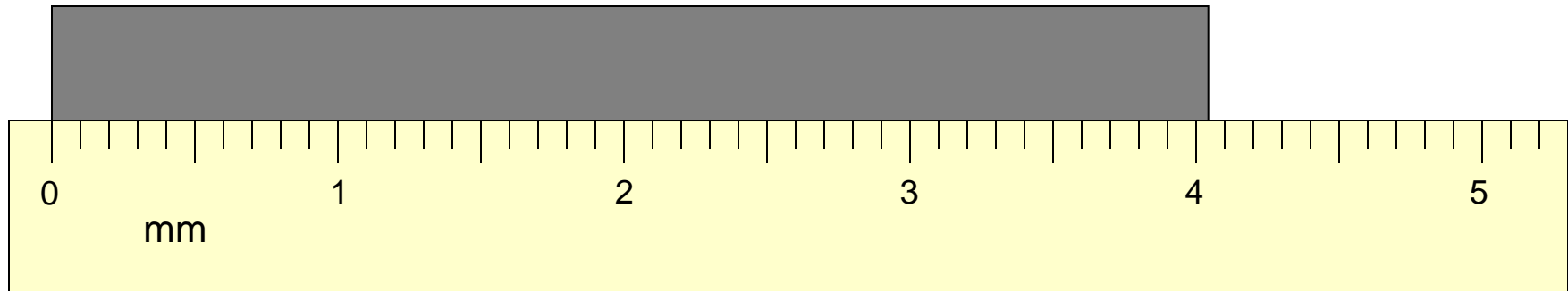
Making Measurements

#18 314 dm



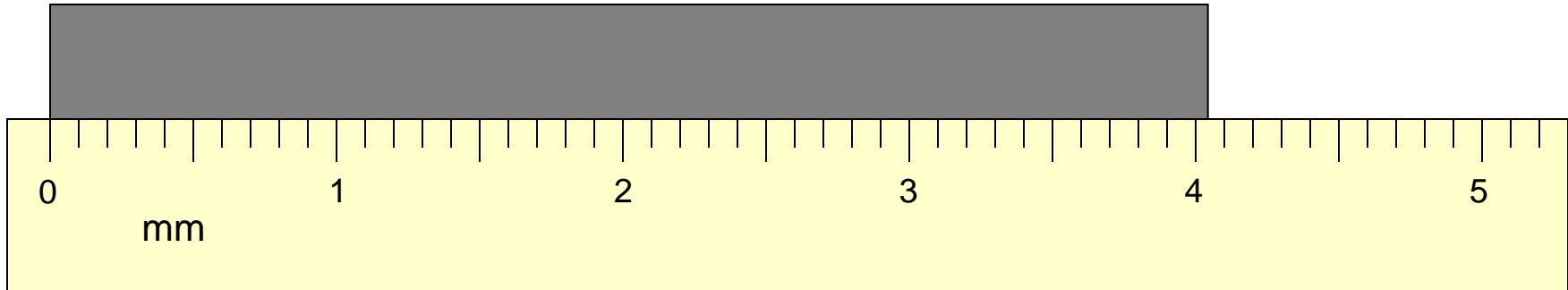
Making Measurements

#19



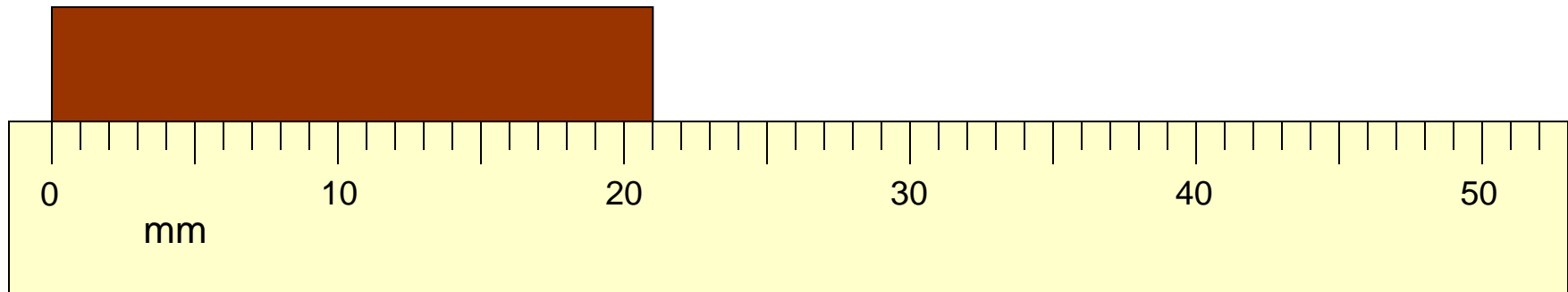
Making Measurements

#19 4.03 mm



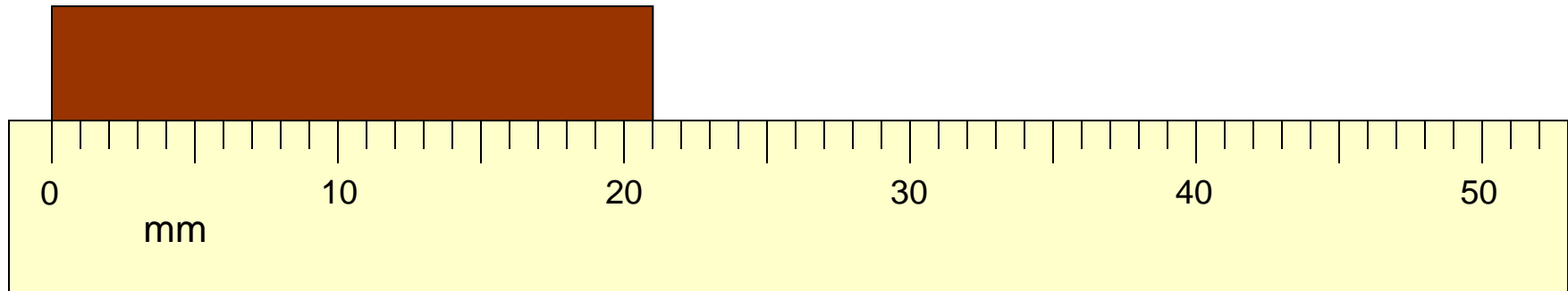
Making Measurements

#20



Making Measurements

#20 21.0 mm

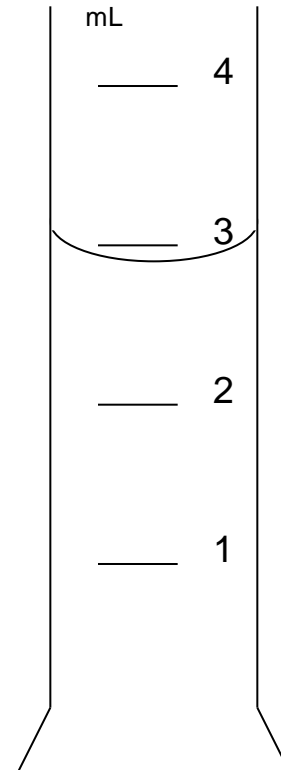


Making Measurements

So far we have been measuring the length of various rectangles. Another measurement that is useful is volume. To measure the volume of a liquid sample, the sample is usually poured into a graduated cylinder.

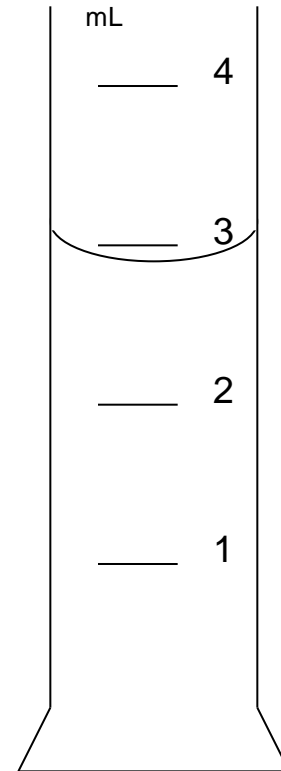
Making Measurements

When this is done, the liquid will often be attracted to the cylinder, and its surface will curve upward on the edges as shown at right:



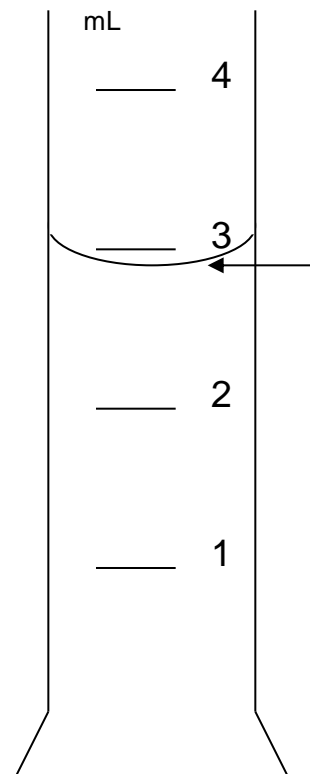
Making Measurements

This curved liquid surface is called a “meniscus,” and it is important to make volume measurements even with the bottom of the meniscus.



Making Measurements

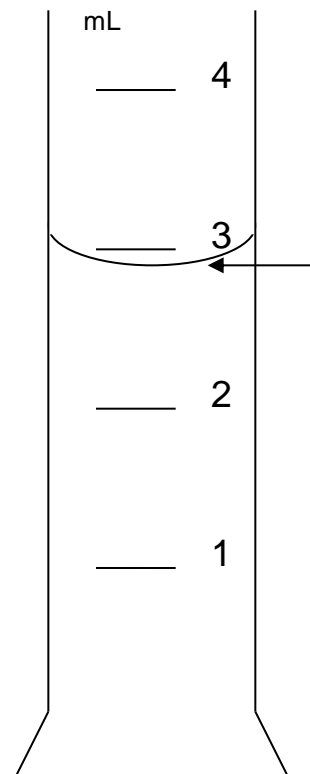
This curved liquid surface is called a “meniscus,” and it is important to make volume measurements even with the bottom of the meniscus.



Making Measurements

This curved liquid surface is called a “meniscus,” and it is important to make volume measurements even with the bottom of the meniscus.

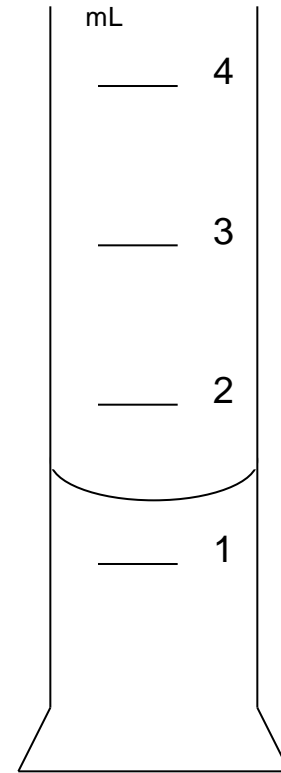
A good reading of the volume of liquid shown at right would be 2.9 mL.



Making Measurements

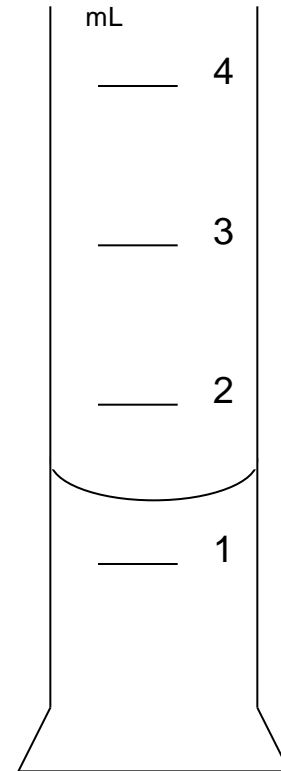
How about the volume of the liquid shown at right?

Again use the scrap paper for your answer, then continue.



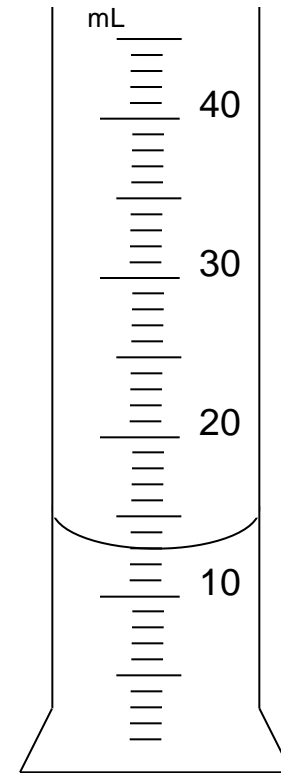
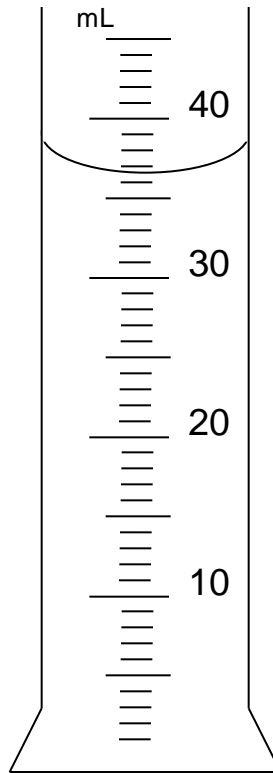
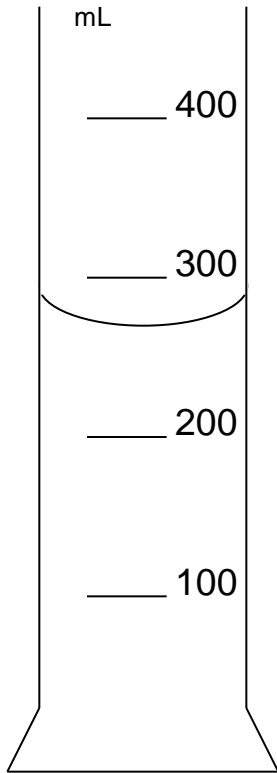
Making Measurements

If you wrote down 1.3 mL (or 1.2 mL or 1.4 mL), then you've measured correctly.



Making Measurements

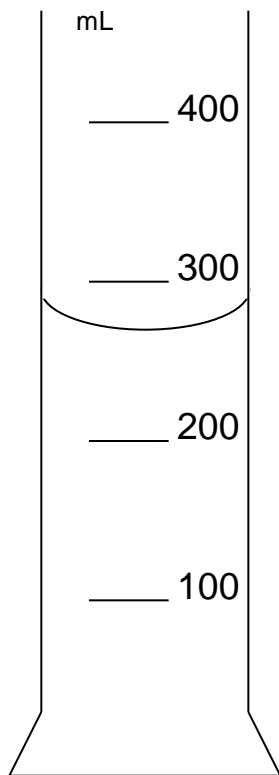
Try these next three volume measurements:



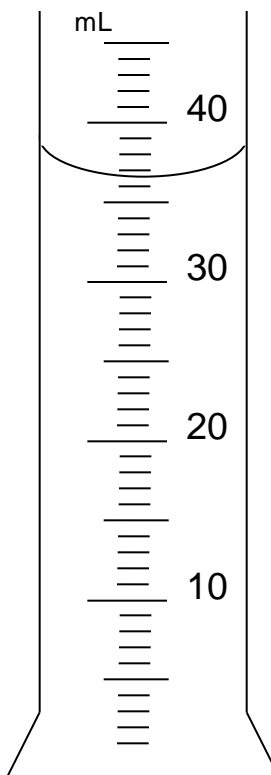
Making Measurements

Did you get these answers???

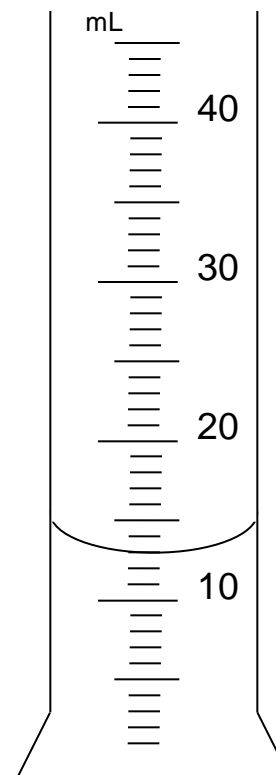
270 mL



36.8 mL

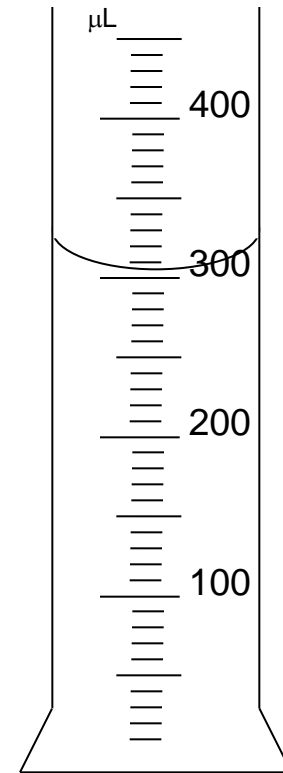
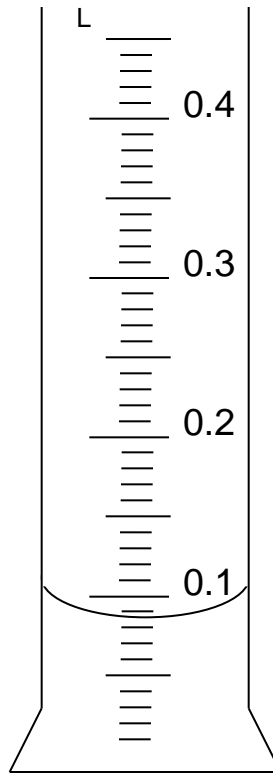
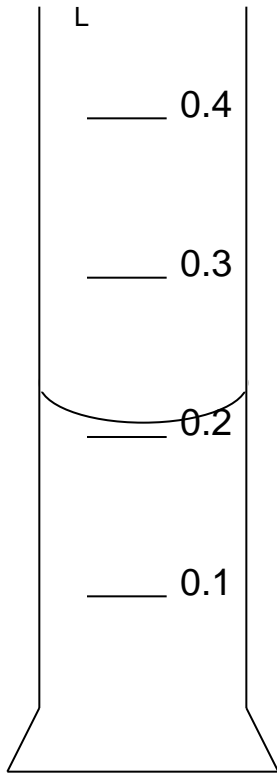


13.0 mL



Making Measurements

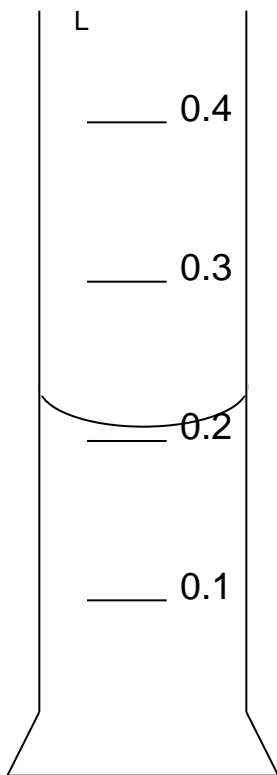
Try three more:



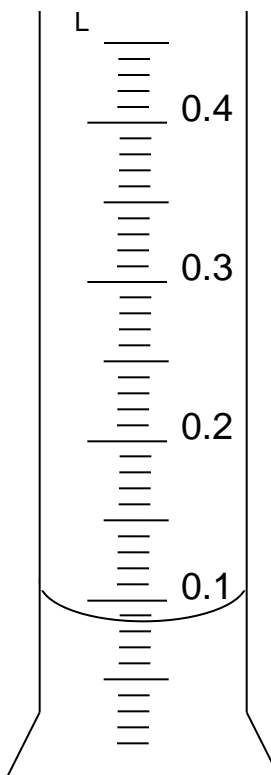
Making Measurements

Did you get these answers???

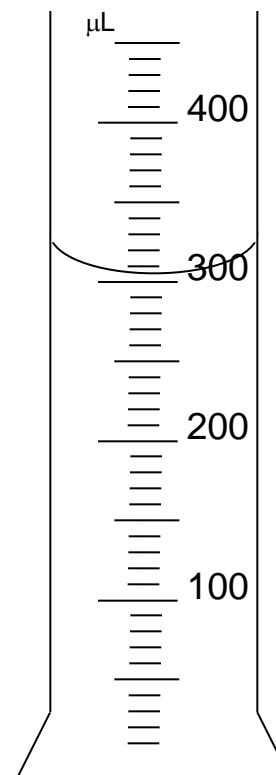
0.21 L



0.088 L



307 μL



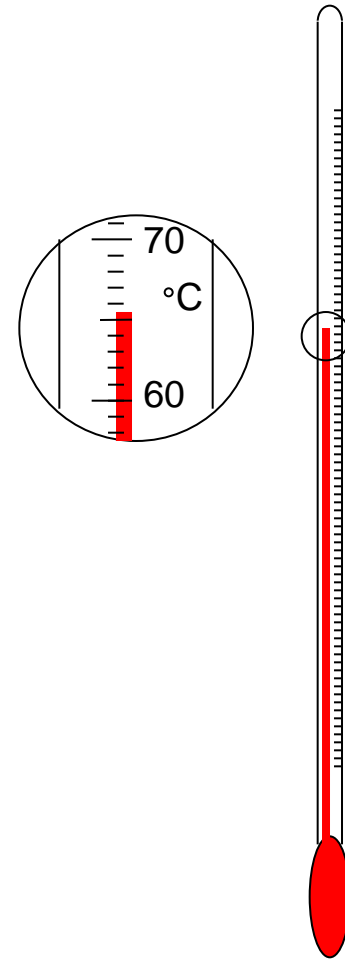
Making Measurements

Thermometers are used for measuring temperature. A colored liquid inside a sealed glass tube expands and contracts as the temperature changes.



Making Measurements

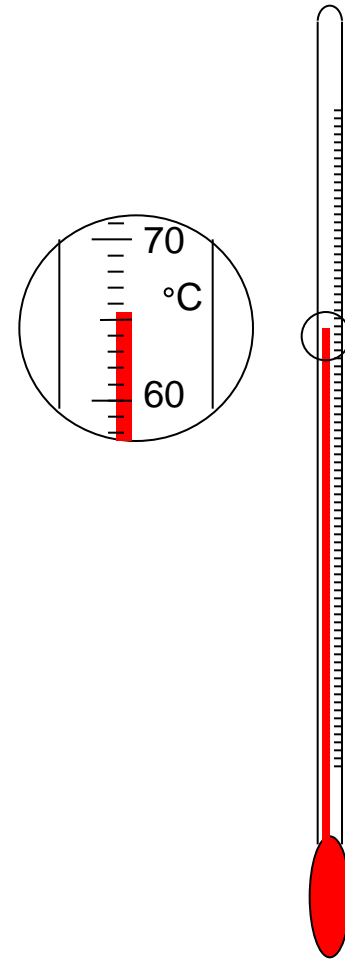
Because the scale is so small,
what is shown at right is a
magnified view of the reading:



Making Measurements

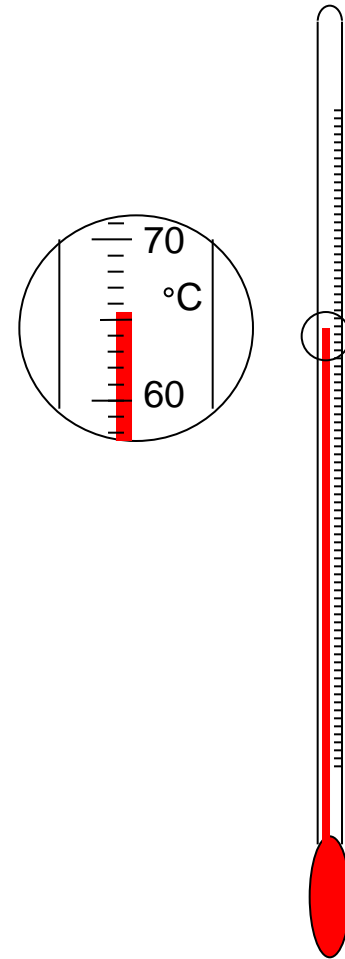
Because the scale is so small,
what is shown at right is a
magnified view of the reading

What is the temperature shown?
(Again, use the scrap paper, then
continue.)



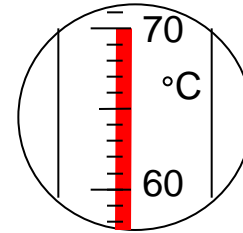
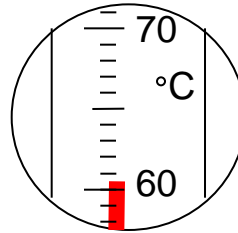
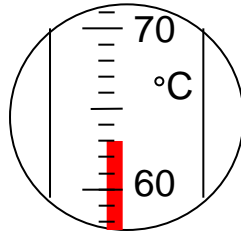
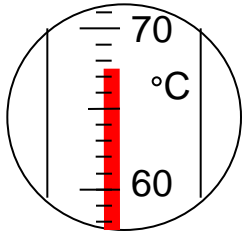
Making Measurements

Did you record the temperature to be 65.3°C ? If so, good job.



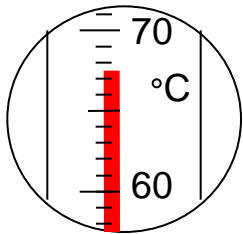
Making Measurements

Try the following four temperature measurements.

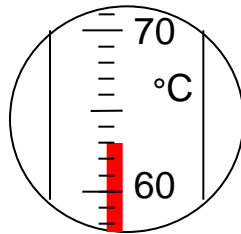


Making Measurements

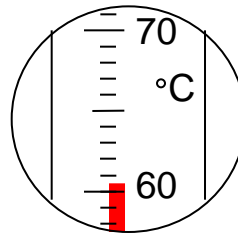
Did you get these answers:



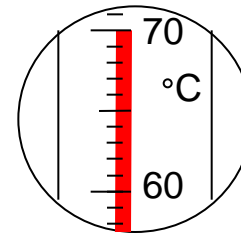
67.5°C



63.0°C



60.6°C



70.0°C

Making Measurements

OK, now one final activity.

Making Measurements

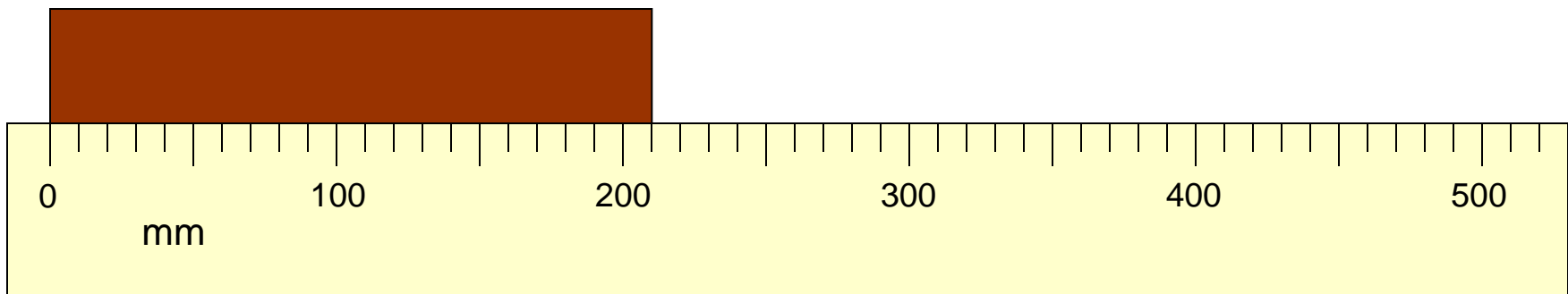
OK, now one final activity. So far you have been given all the diagrams and been asked to make the measurements.

Making Measurements

OK, now one final activity. So far you have been given all the diagrams and been asked to make the measurements. Now let's turn that around...

Making Measurements

On a piece of paper, draw a diagram (like the one below), for which “**4.8 cm**” would be an appropriate reading.

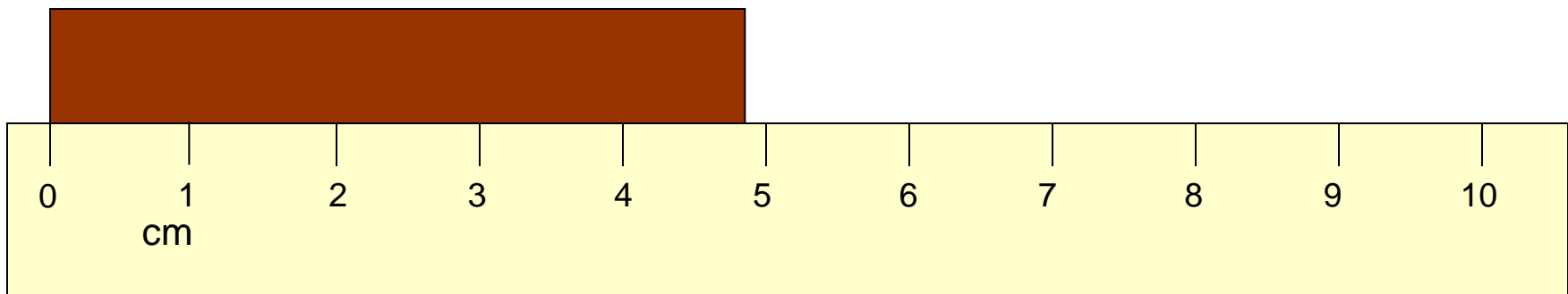


Making Measurements

If you are finished, then continue.

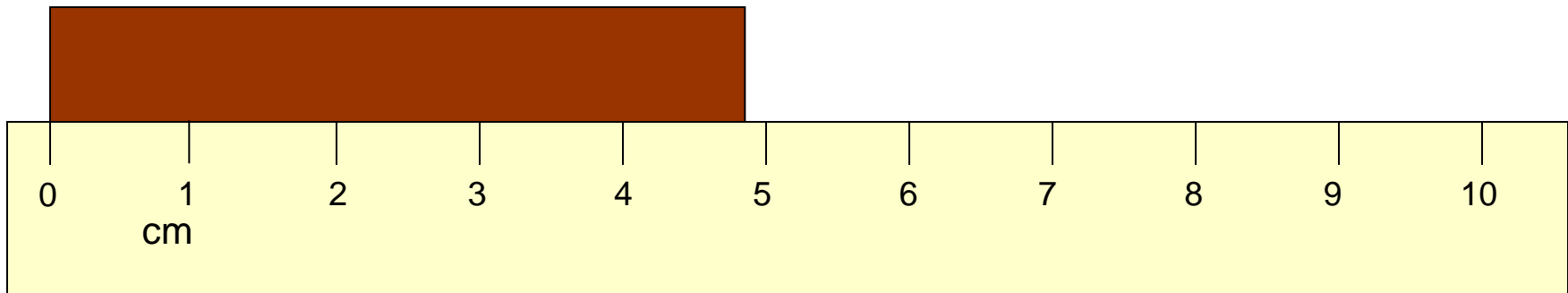
Making Measurements

Does your sketch look like the one below?



Making Measurements

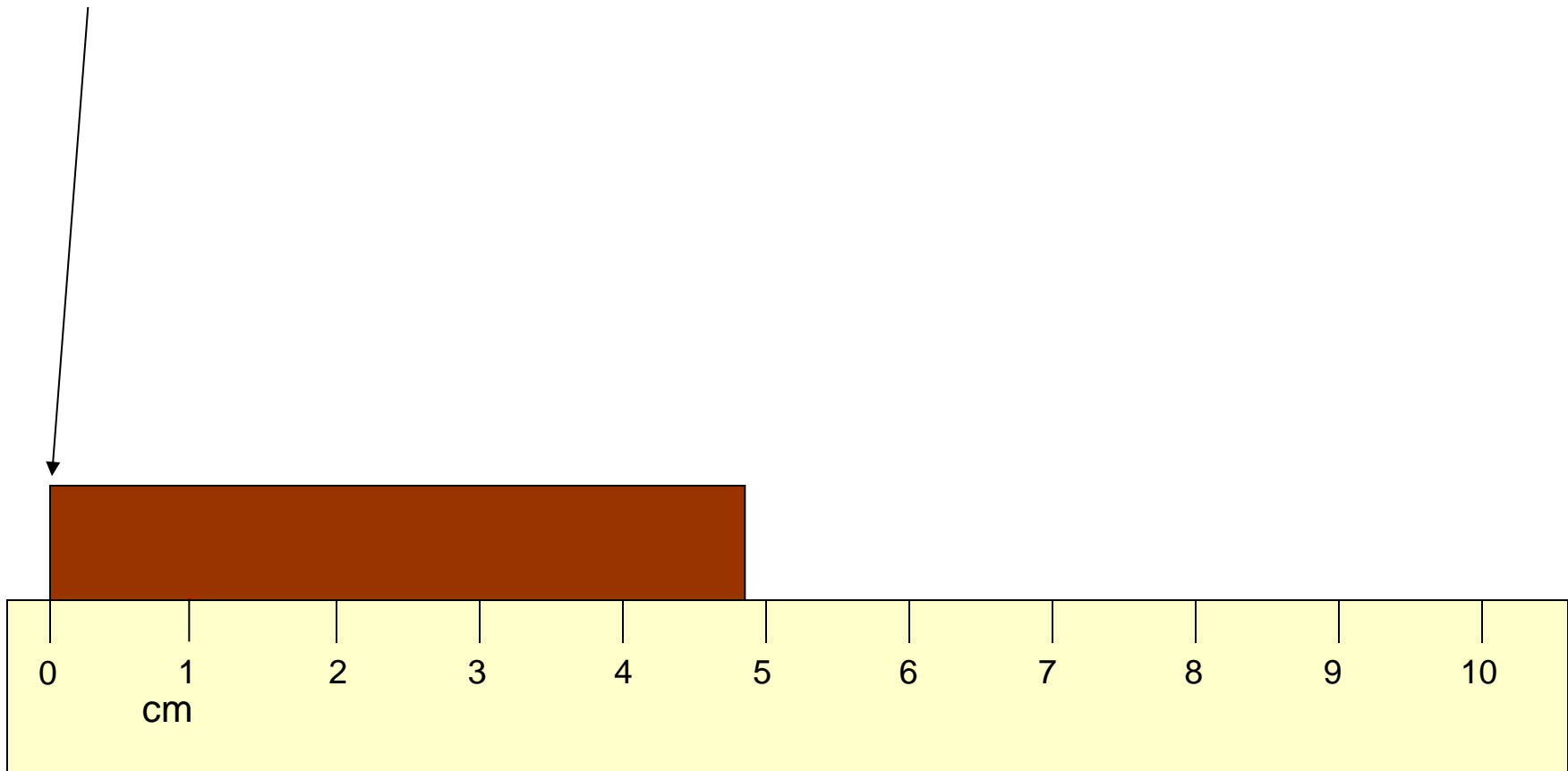
There are four important details:



Making Measurements

There are four important details:

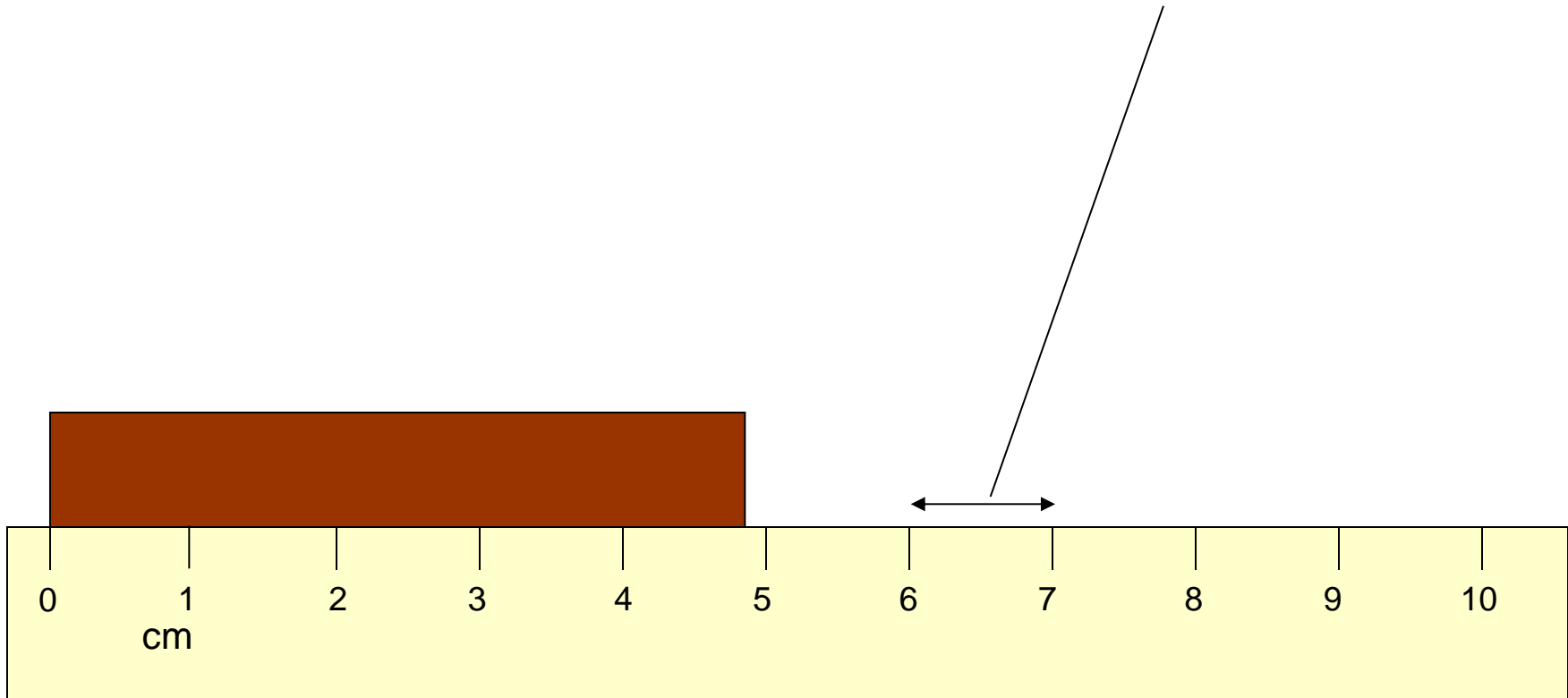
-- The "0" on the scale is indented and lines up with the left-hand edge of the object.



Making Measurements

There are four important details:

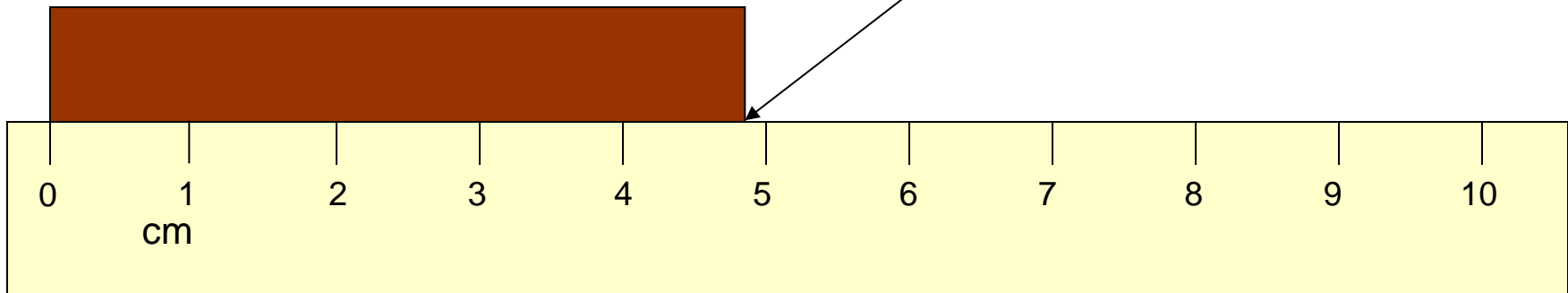
- The "0" on the scale is indented and lines up with the left-hand edge of the object.
- The scale has the correct level of precision: incremented every 1 cm.



Making Measurements

There are four important details:

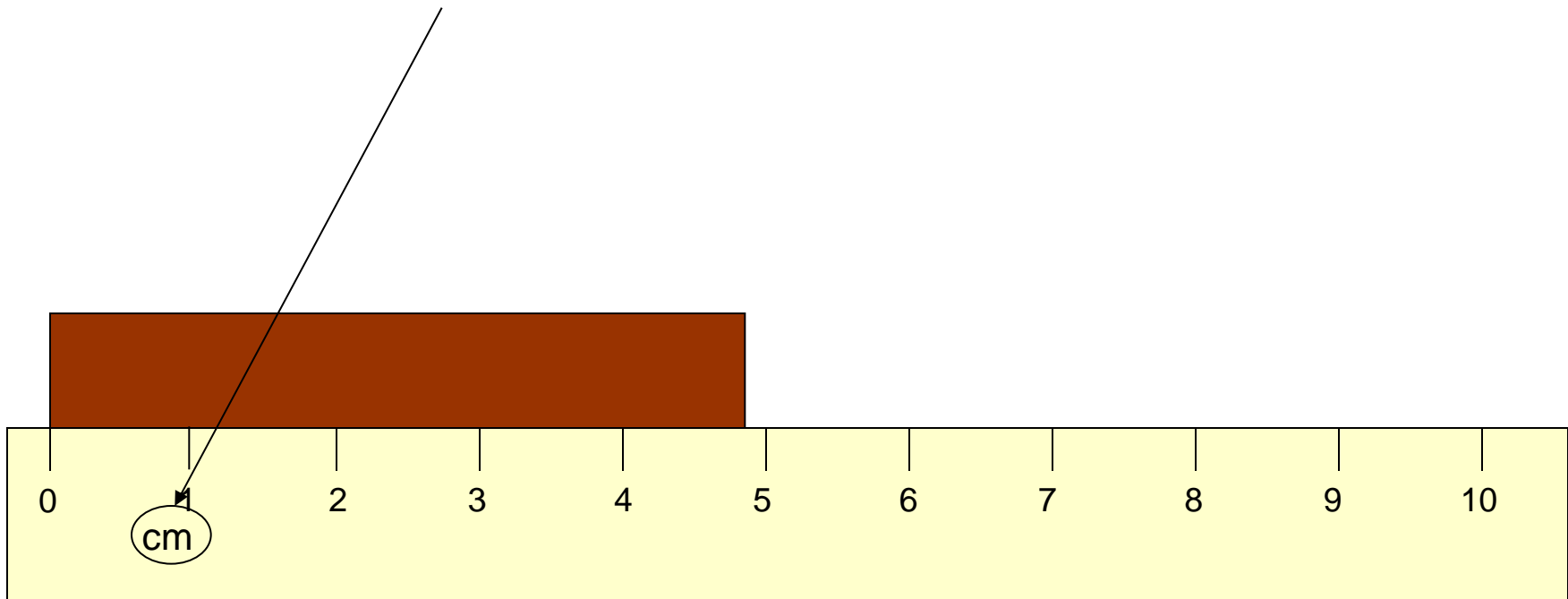
- The "0" on the scale is indented and lines up with the left-hand edge of the object.
- The scale has the correct level of precision: incremented every 1 cm.
- The right-hand edge of the object lands about 8/10's of the way between 4 and 5.



Making Measurements

There are four important details:

- The "0" on the scale is indented and lines up with the left-hand edge of the object.
- The scale has the correct level of precision: incremented every 1 cm.
- The right-hand edge of the object lands about 8/10's of the way between 4 and 5.
- The scale includes the unit.



Making Measurements

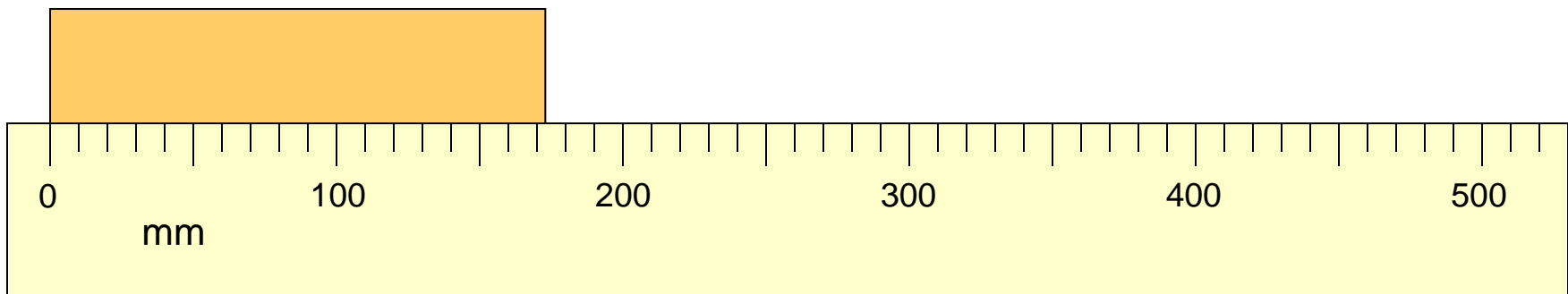
Now try to sketch a diagram for
“172 mm.”

Making Measurements

Now try to sketch a diagram for “172 mm.” When you are done, then continue.

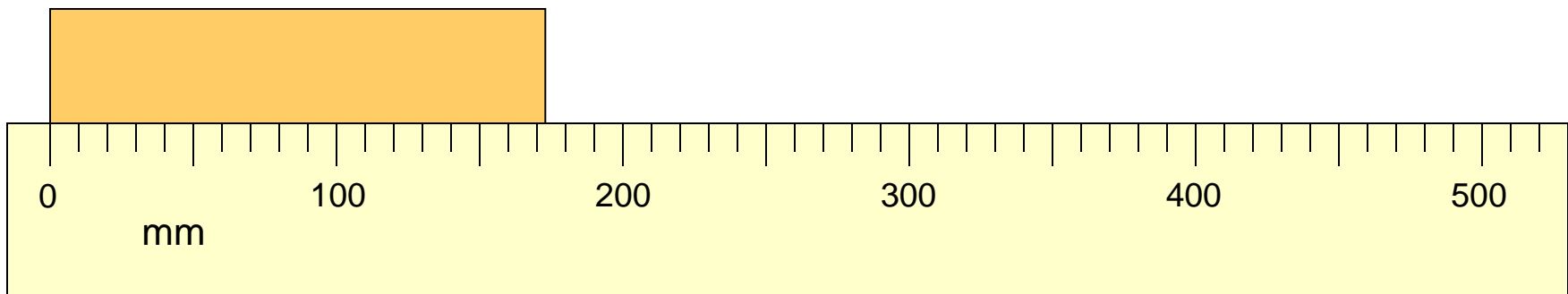
Making Measurements

Now try to sketch a diagram for “172 mm.” When you are done, then continue. Does your sketch look like this?



Making Measurements

Now try to sketch a diagram for “172 mm.” When you are done, then continue. Does your sketch look like this: If so, you’re right.



Making Measurements

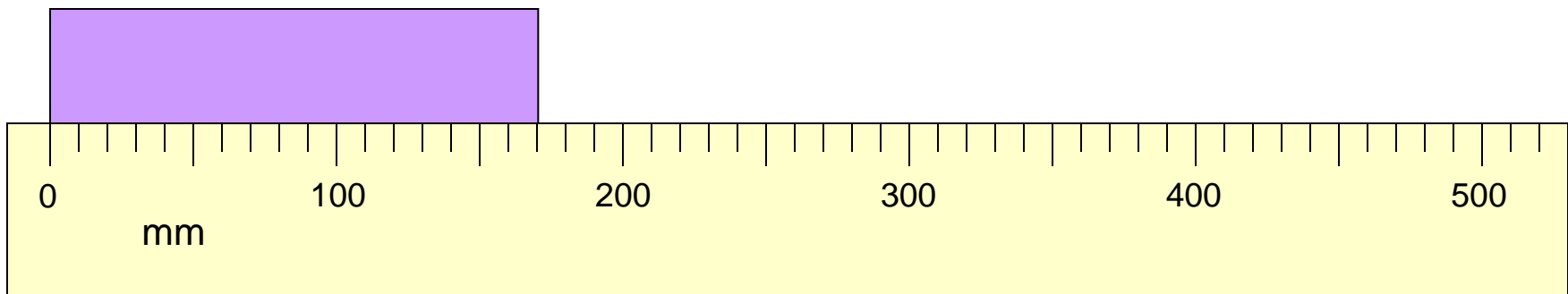
Now try to sketch a diagram for
“170 mm.”

Making Measurements

Now try to sketch a diagram for “170 mm.” When you are done, then continue.

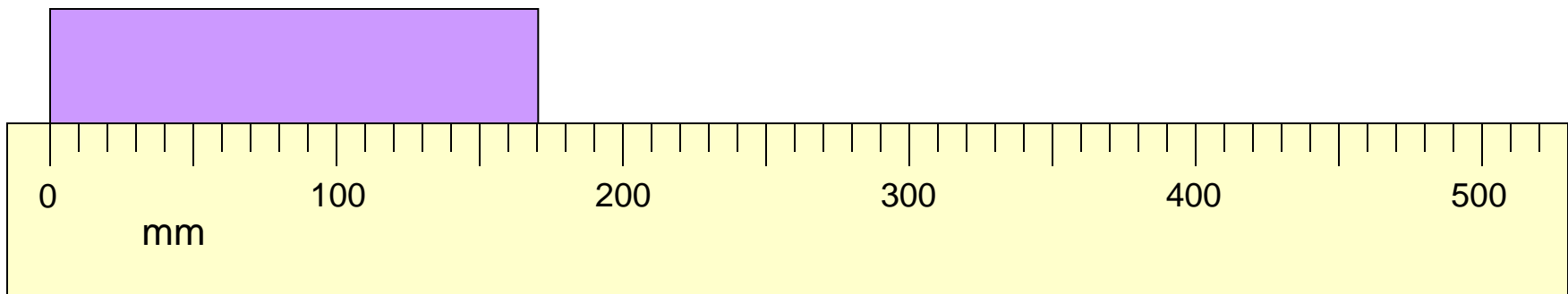
Making Measurements

Now try to sketch a diagram for “170 mm.” When you are done, then continue. Does your sketch look like this?



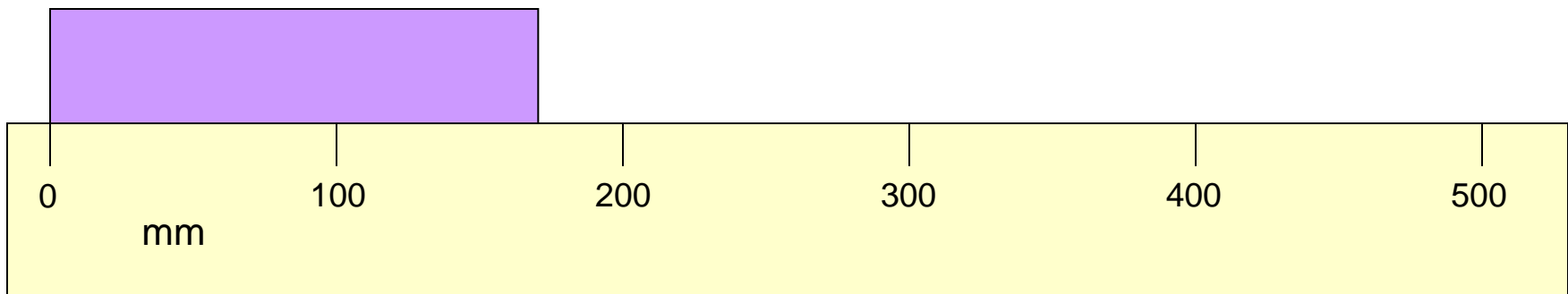
Making Measurements

Now try to sketch a diagram for “170 mm.” When you are done, then continue. Does your sketch look like this? If so, it’s **WRONG!**



Making Measurements

In “170 mm,” the “7” is the guess. The correct diagram for “170 mm” would look like this:



Making Measurements

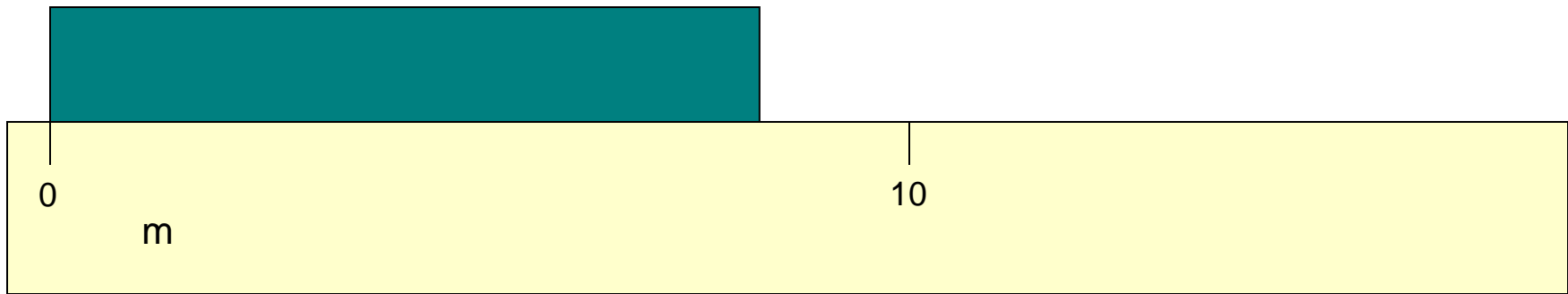
Now try to sketch a diagram for
“8 m.”

Making Measurements

Now try to sketch a diagram for “8 m.” When you are done, then continue.

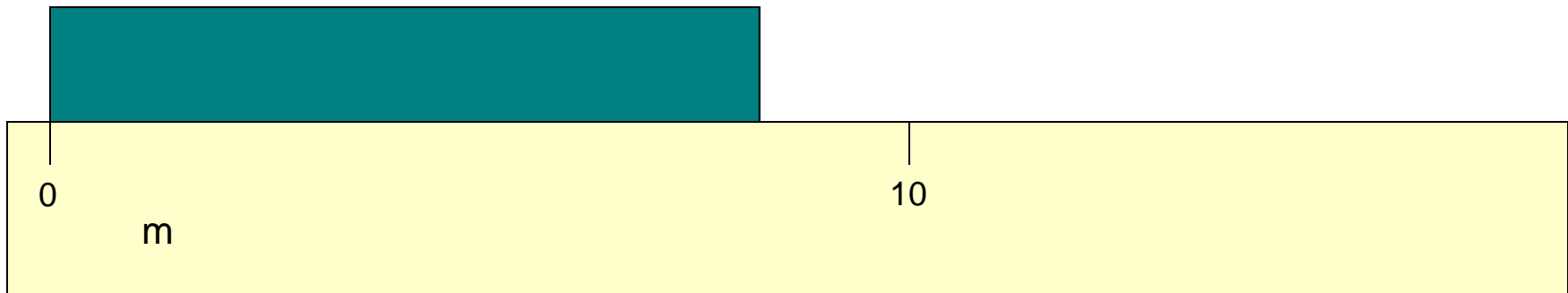
Making Measurements

Now try to sketch a diagram for “8 m.” When you are done, then continue. Does your sketch look like this?



Making Measurements

Now try to sketch a diagram for “8 m.” When you are done, then continue. Does your sketch look like this? If so, good job.



Making Measurements

Now try to sketch a diagram for
“23.0 mL.”

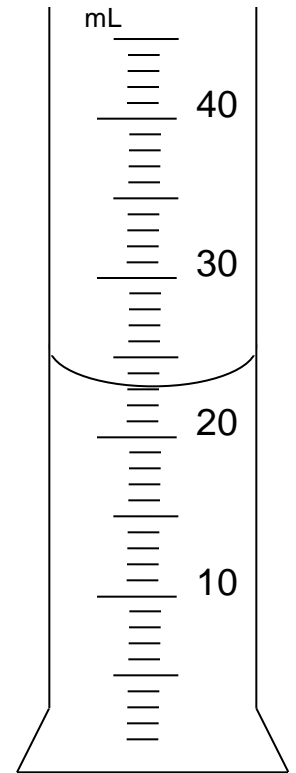
Making Measurements

Now try to sketch a diagram for “23.0 mL.” When you are done, then continue.

Making Measurements

Now try to sketch a diagram for “23.0 mL.” When you are done, then continue.

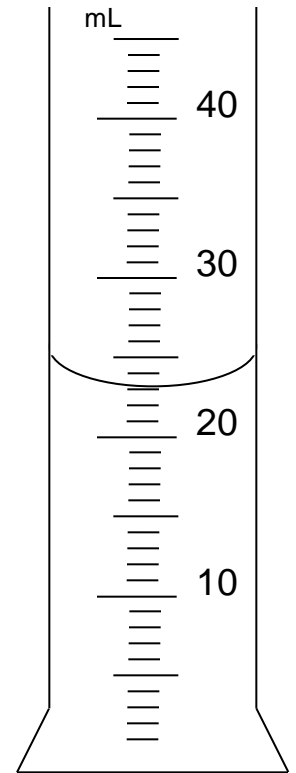
Does your sketch look like this?



Making Measurements

Now try to sketch a diagram for “23.0 mL.” When you are done, then continue.

Does your sketch look like this? If so, good job.



Making Measurements

Well, hopefully in this tutorial, you have learned how to make measurements that reflect the precision level of the equipment being used.

Making Measurements

In future tutorials you will learn how to use these measurements in calculations and how the values derived from these calculations also reflect the level of precision of the equipment used.