H #1 - Measurement & Place Value

What digits are significant when recording a measurement?

Why?

Scientists do a lot of measuring. When scientists use an instrument (such as a ruler, graduated cylinder, spectrophotometer or balance) to measure something, it is important to take full advantage of the instrument. However, they can't cheat and record a better measurement than the instrument is capable of. There is an understanding among scientists of the proper way to record valid measurements from any instrument. When you are the scientist, you must record data in this way. When you are reading other scientists’ work, you must assume they recorded their data in this way.

Model 1 – Ruler A

<table>
<thead>
<tr>
<th>Name</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Susan</td>
<td>3 cm</td>
</tr>
<tr>
<td>Maya</td>
<td>2 cm</td>
</tr>
<tr>
<td>Jonah</td>
<td>2.5 cm</td>
</tr>
<tr>
<td>Tony</td>
<td>3.00 cm</td>
</tr>
<tr>
<td>Emily</td>
<td>3 1/4 cm</td>
</tr>
<tr>
<td>Dionne</td>
<td>3.33 cm</td>
</tr>
</tbody>
</table>

1. What are the only 2 distances that you can be certain of on the ruler in Model 1?

The only two distances that are marked on the ruler are 0 cm and 10 cm.

2. Six students used the ruler in Model 1 to measure the length of a metal strip. Their measurements are shown at the right. Were all of the students able to agree on a single value (1, 2, 3...) for any digit (ones place, tenths place, etc.) in the measurement?

The six students were not able to agree on a single value for any digit.

3. The ruler in Model 1 is not very useful, but measurement can be estimated. Discuss in your group how each student might have divided up the ruler “by eye” in order to get the measurement that he or she recorded and list (or sketch) the major strategies you agree upon in the space below.

visualize & annotate - breaking segments into “halves” can help estimate

4. The students obtained a better ruler, shown in Model 2. What 11 distances can you be certain of on this ruler?

   **We can be certain of the ones place! 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 cm**

5. Were the students able to agree on a single value (1, 2, 3...) for any digit (ones place, tenths place, etc.) in their measurements using the ruler in Model 2? If yes, what value in what digit did they agree on?

   **All students agreed upon 3 in the ones place**

6. What feature in Model 2 (that was absent in Model 1) allowed students to agree on a value in that digit/place?

   **Markings (gradations) on the ruler showed with certainty the ones place. In other words, the ruler had a resolution of 1 cm, allowing everyone to come to the same conclusion in the ones place.**

**Model 3 – Ruler C**

7. The students obtained an even better ruler, shown in Model 3. Were the students able to agree on a single value for any of the digits in their measurements using the new ruler? If yes, what value(s) did they agree on in which digits?

   **Students were able to agree upon 3 in the ones place and 2 in the tenths place.**

8. Was it reasonable for Jonah to estimate 2.5 cm in Model 1? Would it be reasonable for Jonah to estimate 2.5cm in Model 3? Why?

   **In model 1, it was reasonable for Jonah to estimate 2.5 cm (though it is unlikely that he could really estimate to the tenths place with confidence since the ruler had a resolution of 10cm) because the object appeared to take up approximately 1/4 of the whole ruler, and 1/4 of 10 is 2.5cm. However, in model 3 it would not be reasonable for Jonah to estimate 2.5 cm because the ruler has a might higher resolution (smaller markings) that allows us to see that object is clearly larger than 3.2 cm but smaller than 3.3 cm. Therefore Jonah should estimate 3.2_ where the _ is his estimate of how far between 3.2 and 3.3 the object reaches.**

Read This!

When humans use measuring instruments, variation is expected. Everyone will estimate differently between marks on the instrument. On the other hand, digits that are certain (based on marks on the instrument) should not vary from person to person.

Model 4 – Valid Measurements

<table>
<thead>
<tr>
<th>Ruler A</th>
<th>0 cm</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ruler B</th>
<th>0 cm</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ruler C</th>
<th>0 cm</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

9. The measurements taken in Models 1–3 have been combined in Model 4. The measurements that follow the rules of measurement agreed upon by scientists are in the “Valid Measurements” column. Those that do not follow the rules are in the “Invalid Measurements” column. **For each valid measurement shown in Model 4, draw a square around the certain digits (if any) and circle the digits that were estimated (if any).**

10. Based on the examples in Model 4, circle the best phrase in the parenthesis to complete each sentence below.

a. In a valid measurement, you record **zero, one, two** estimated digit(s).

b. In a valid measurement, the estimated digit is the **first digit, second to last digit, last digit** in the measurement.

c. In a valid measurement, the estimated digit corresponds to **the largest marks, the smallest marks, one tenth of the smallest marks** on the instrument.

11. Using Ruler B from Model 4, Dionne recorded a measurement of 3.20 cm, which was invalid. But when Maya made the same measurement using Ruler C, it was considered valid. Explain why the zero was recorded because Maya had a resolution (smallest markings) of 1 cm, which is the ONES place. This means that it is only valid to estimate in this measurement using one place value further than the ones place, which is the TENTHS place. Dionne should have recorded 3.2 cm as their estimation for Ruler B, not 3.20. In Ruler C, a measurement of 3.20 was acceptable because the resolution of the ruler was 0.1 cm, which is the TENTHS place, so estimating the HUNDREDTHS place is valid.

12. A student recorded the length of a test tube as 5.0 cm. Which ruler in Model 4 was the student using? Explain. **Work backwards here! If the student rounded to the tenths place, the ruler had to go only to the ones place, so it had to be Ruler B!**

13. In Model 4, Ricky recorded his measurement 3.19 cm using Ruler C. His classmates thought he was wrong because his second digit was not “2.” However, Ricky’s recorded measurement is perfectly valid. Explain. **He rounded to the hundredths place, which is the correct place to round to. It’s ok that he thought that the measurement was 3.19 instead of 3.20, because it was an estimate and close.**

14. The resolution of the ruler below is **1** cm so we must record measurements to the **tenths** place. Record the length of the wooden splint below to the correct number of digits based on this measurement tool.

```
0 cm _______ _______ _______ _______ _______ 10
```

*Any answer around 7.0 as long as you went to the tenths place is acceptable and valid!*

15. The resolution of the ruler below is **0.1** cm so we must record measurements to the **hundredths** place. Record the length of the wooden splint below to the correct number of digits based on this measurement tool.

```
0 cm _______ _______ _______ _______ _______ 10
```

*Any answer around 7.00 as long as you went to the hundredths place is acceptable and valid!*

16. When using an electronic device, such as an electronic balance, the measurement displayed on the screen is assumed to have one estimated digit included. In fact, you’ll often see the estimated digit changing rapidly, because there is fluctuation in the estimate. Explain why it is important to record the zero in the measurement shown to the right.

*electronic tools always report the correct number of estimated and certain digits, so it’s important to write down all numbers that they give you!*

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1) Determine the resolution (resolution = grids) on each of the different graduated cylinders below.

![Graduated Cylinders](image)

a) _______  b) _______  c) _______  d) _______

2) Read the volume of each of the following. Estimate one place beyond the graduations.

![Volume Measurements](image)

Example  a) _______  b) _______  c) _______  d) _______

*If your LAST (estimated) digit is different from mine, your measurement is still valid - as long as you use the same place values as I did!*

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3) Draw in the meniscus for the following readings:

a) 49.21 mL  b) 18.2 mL  c) 27.65 mL  d) 63.8 mL

Name____________________
Date_________ B____