Name: _____     Date: _____

## Evidence Collection: Importance of Measurements and Data Reporting

Because evidence collected at the crime scene may have to be analyzed using several laboratory methods, it is important for investigators to know how large a sample to collect. If an insufficient sample is collected, the laboratory might not be able to completely analyze the evidence. On the other hand, forensic crime laboratories are often backlogged with evidence to analyze, which can create problems for storage it needlessly large samples are collected from crime scenes. Therefore, most crime laboratories publish guidelines for sample size.

### Model 1 – Ruler A

| Susan | 3 cm |
| Maya | 2 cm |
| Jonah | 2.5 cm |
| Tony | 3.00 cm |
| Emily | 3¼ cm |
| Dionne | 3.33 cm |

0 cm                                                          10

1.  What measurement for the metal strip can you be certain of in Model 1?

2.  Six students used the ruler in Model 1 to measure the length of the 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? If yes, which value and digit did they agree on?

3.  The ruler in Model 1 is not very useful, but a 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.

**Model 2 – Ruler B**



| | |
|---|---|
| Susan | 3.2 cm |
| Maya | 3.1 cm |
| Jonah | 3.3 cm |
| Tony | 3 cm |
| Emily | 3.25 cm |
| Dionne | 3.20 cm |

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

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

6. What feature of the ruler in Model 2 made it possible for the students to agree on a value in that digit?

7. There will always be uncertainty in any measurement. This causes variation in measurements even if people are using the same instrument. Compare the variation in the measurements made by six students using the rulers in Models 1 and 2. Which ruler resulted in greater variation? Explain why that ruler caused more variation.

**STOP** Review your answers above in preparation for a mini-quiz on what you have learned about variation in recorded measurements.

**Model 3 – Ruler C**



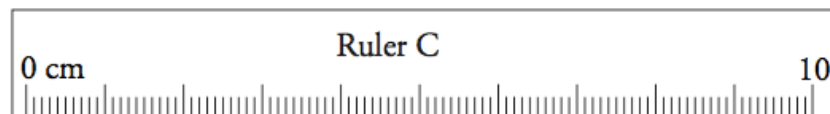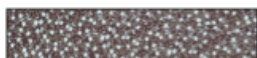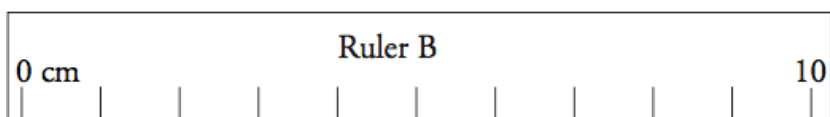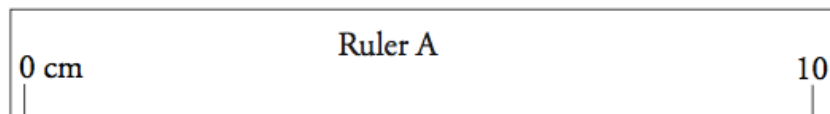| | |
|---|---|
| Susan | 3.21 |
| Maya | 3.20 cm |
| Jonah | 3.22 cm |
| Mark | 3.2 cm |
| Emily | 3.215 cm |
| Dionne | 3.205 cm |

8. The students obtained an even better ruler, shown in Model 3.
   a. Where 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?

   b. What feature of the ruler in Model 3 made it possible for the students to agree on the values in those digits?

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

|  | Valid Measurements | Invalid Measurements |
|---|---|---|
| **Ruler A** (0 cm – 10) | 3 cm<br>2 cm | 2.5 cm<br>3.00 cm<br>3¼ cm<br>3.33 cm |
| **Ruler B** (0 cm – 10) | 3.2 cm<br>3.1 cm<br>3.3 cm | 3 cm<br>3.25 cm<br>3.20 cm |
| **Ruler C** (0 cm – 10) | 3.21 cm<br>3.22 cm<br>3.20 cm | 3.2 cm<br>3.215 cm<br>3.205 cm |

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 certain digits (if any) and circle the digits that were estimated (if any).
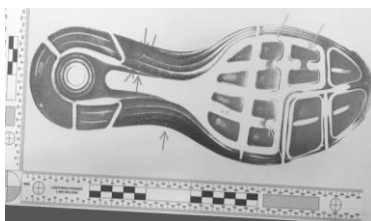
🛑 **STOP** Review your answers above in preparation for a mini-quiz about the estimated digit in the recorded measurements.

13. Using Ruler B from Model 4, Tony recording measurement 3 cm. Explain why this was an invalid measurement.

14. 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 went zero is acceptable when using Ruler C, but not when using Ruler B.

15. A student recorded the length of a test tube as 5.0 cm. Which ruler in Model 4 was the student using? Explain.

16. 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.

**Read This!**

In making measurements for scientific purposes, we intentionally include one number that is an estimate in every measurement. It seems odd, but by including one digit that is an estimate (which means it may contain error), the measurement is actually more accurate than if we used only the digits that are exactly known. Consider this shoe print found at a crime scene. How would an investigator report the width of the print? It is greater than 11 cm but less than 12 cm. Depending on the person, estimates of the width might range from 11.4 cm to 11.6 cm, all those estimates are acceptable. Because the last decimal place is an estimate, it will vary from one person's observation to another. The rule in the laboratory is that we keep all digits that are known exactly, Plus one digit that is an estimate and contains some error. Collectively, these digits are called **significant figures**.

17. Record the length of the wooden splint to the proper number of significant figures.
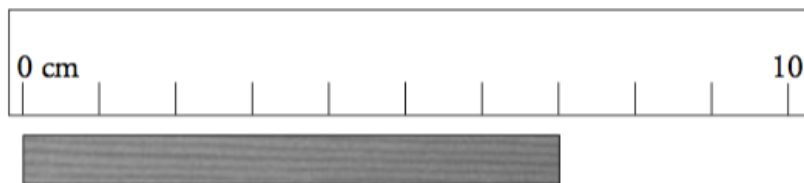
18. Record the length of the wooden splint to the proper number of significant figures.
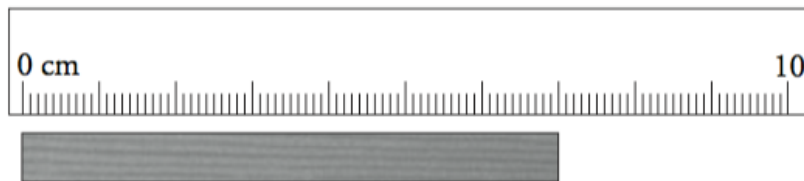
**STOP** Review your answers above in preparation for a mini-quiz on recording the length of an item to the proper number of significant figures.

19. When using an electronic device, such as an electronics 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.

1.20 g

1000
900
800
700
600
500
400
300
200
100

20. Consider the 1000 mL graduated cylinder to the right with marks every 100 mL.
    a. A student records the volume of liquid in the cylinder as 760 mL. Is this a correct measurement? Explain.
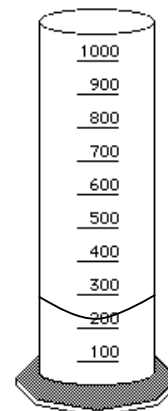
b.  Are all of the digits in the described measurement of 760 mL significant? Explain.

21. A student properly records the length of a block as 330 cm. Draw the markings on the ruler that was used to measure the block.

0 cm