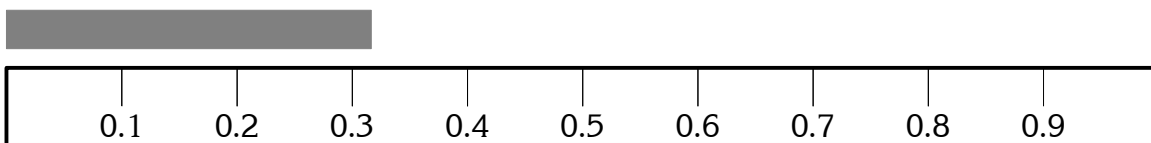


Measuring Precisely

Any time you read a scientific instrument, you should try to be as precise as you can. That is, measure carefully and use all the information the instrument can give you:

- If the thing you're measuring is between two marks on the instrument, estimate how far between it is so you can put an extra digit in your number.
- If the thing you're measuring is exactly on a line, put a zero as the extra digit.

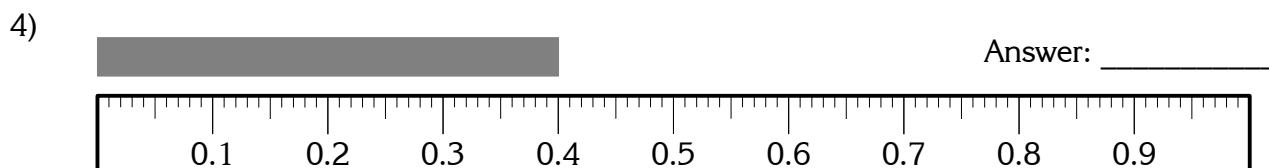
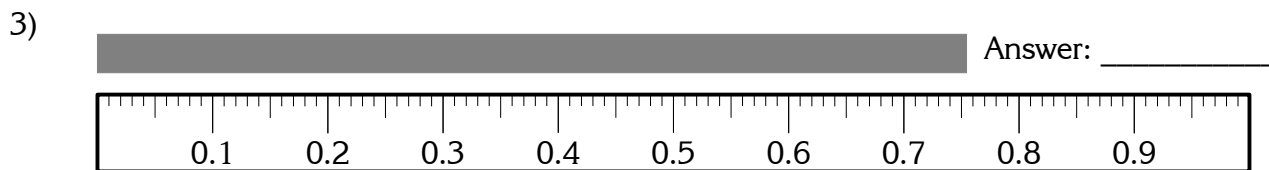
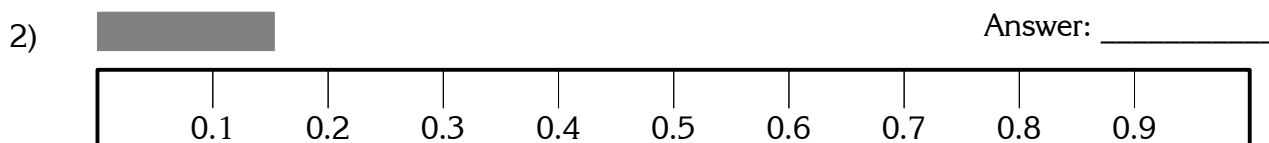
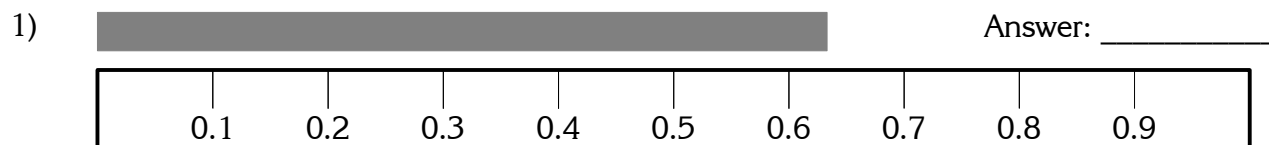
For example, the ruler below is a meter stick divided into sections 0.1 m long. It can be used to record measurements such as 0.23 m, 0.59 m, or 0.40 m by estimating the final digit.



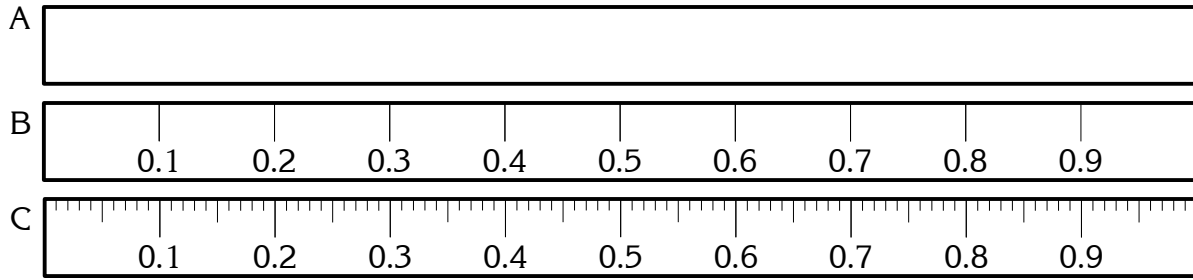
The gray bar above the ruler has a length that is definitely more than 0.3 m, but definitely less than 0.4 m. An estimate of 0.31 m or 0.32 m would be a good measurement of the bar.

Measuring on rulers

Estimate the length of each gray bar to the proper level of precision for the meter stick shown. Please use meters as your unit!!!



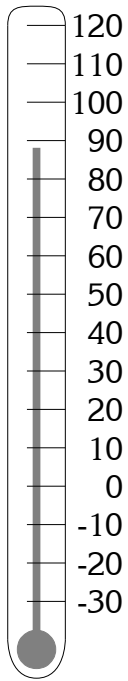
Here are three different meter sticks, labeled A, B, and C:



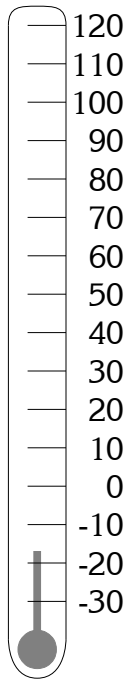
For each measurement below, state which meter stick was used to make the measurement. (Numbers bigger than 1 m can be measured by using multiple meter sticks or by moving the meter stick.)

- | | |
|------------------|--------------------|
| 5) 0.95 m _____ | 10) 3.9 m _____ |
| 6) 0.3 m _____ | 11) 2.05 m _____ |
| 7) 0.54 m _____ | 12) 2.00 m _____ |
| 8) 0.540 m _____ | 13) 13.1 m _____ |
| 9) 0.9 m _____ | 14) 22.931 m _____ |

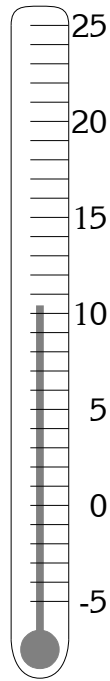
On these drawings of thermometers, read the temperatures to the proper number of digits. The thermometers are all in °C.



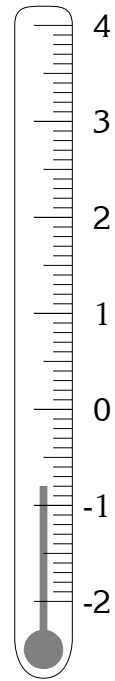
15) _____



16) _____



17) _____

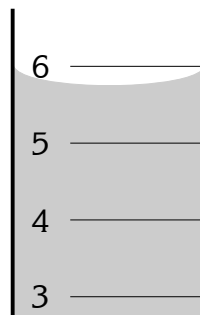


18) _____

Graduated cylinders are one way of measuring **volumes**. (*Volume* is the amount of space that something takes up.) When you place liquids into a graduated cylinder, the surface of the liquid usually curves a little at the edges. Most liquids curve up, but some curve down. This curved shape is caused by surface tension and is called a **meniscus**.

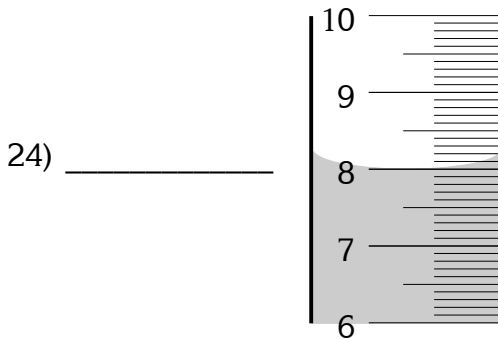
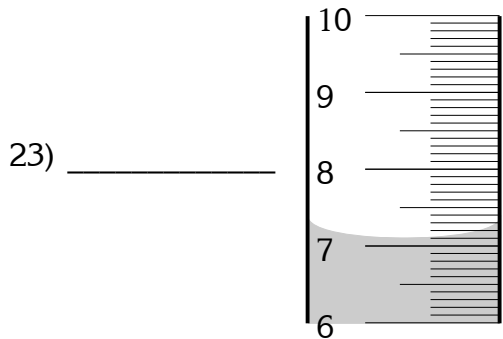
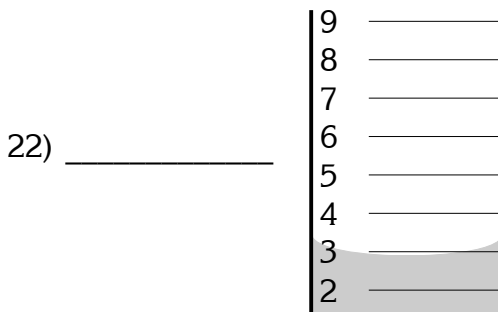
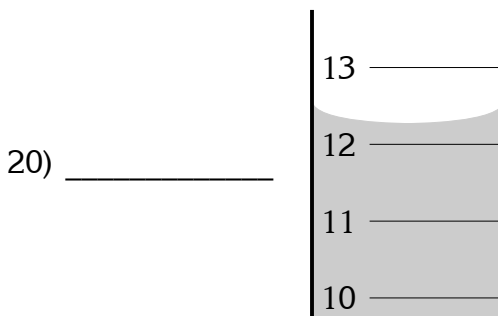
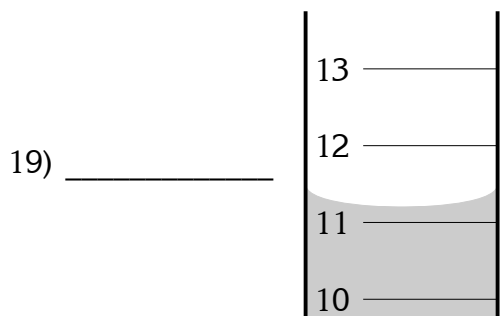
Graduated cylinders are designed to be read from the center of the meniscus, not the edges.

Read the graduated cylinders below. They are all labeled in units of milliliters (mL).



Read a graduated cylinder from the center of the tube, not the edges!

This cylinder reads about 5.7 mL.



Answer the following questions with what you've learned so far about measurement. Even if you collaborate with other students on this, you need to write your answers in your own words.

25) Why do we have to make estimations when measuring things in science?

26) Do you think estimating the final digit makes measurements more precise, less precise, or neither? Explain why.

27) Do you think estimating the final digit makes measurements more accurate, less accurate, or neither? Explain why.