PHYSICS 534

ANSWERS

EXERCISE-02 Measurements

LORENTZ

Hendrik Lorentz received the Nobel prize for physics in 1902 for his work on magnetism in radiation.

Physics is a quantitative science concerned with the relationships between careful measurements of well-defined physical quantities. As such, measurement comes first in physics. Indeed, as a science student, it is very important that you learn well the ***art*** of measurement.

A measurement, which is a quantitative observation, is nothing more than a comparison. In order to make a measurement, we must first establish some standard units. Then, using these standard units, we measure an unknown quantity by comparing it to the standard unit. Every measurement includes three things:

① The quantity measured (distance, mass, time, speed, etc.)
② The magnitude or size (a number)
③ The unit (metre, kilogram, second, metres-per-second, etc.)

- **Counting versus Measuring**

You should realize that counting always results in **exact** numbers while measurements always result in **approximate** numbers. No matter how accurate a measuring instrument is and no matter how much expertise the person making the measurement has, the results of a measurement will **always** be approximate.

- **Accuracy versus Precision**

By definition, accuracy means how close a measured value is to the accepted standard value. Precision means how close together a series of measurements are. That is, precision refers to the **reproducibility** of a series of measurements.

Believe it or not!

As you know, matter is made up of atoms each of which contains electrons.
How many electrons are there in the universe? A large number, correct?
Yet the following number is ***greater*** than ***all*** the electrons in the **universe!**

2^{200} = 1606938044225899027554196209234116260252220299378279283530137 6

1. What is the difference between "counted" numbers and "measured" numbers?

Counted numbers result from counting, measured numbers result from a measurement. Note that while counted numbers are exact, measured numbers are always approximate.

2. Can a measurement ever produce an exact number? **No** Why?

Because measurement, by its nature, is an approximate process. Indeed, in all measurments, the least significant digit (the last number on the right), is always the result of a "guess" on the part of the measurer (observer).

3. What is the significance in reporting a measured value as 66.0 rather than 66?

The number 66.0 is more precise than the number 66.

4. What are the two main causes of uncertainty in a measurement?

① **The measuring instrument is not perfect.**

② **The observer (measurer) is not perfect.**

5. How many uncertain digits do all measured values have? **One**

6. Define "order of magnitude".

The approximate size of a quantity (in powers of 10).

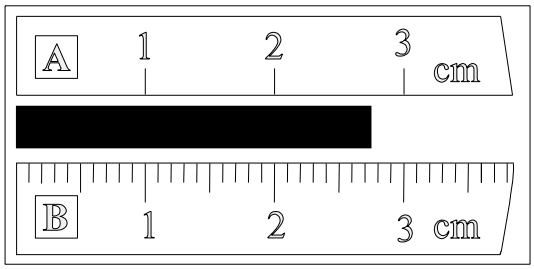
7. Below are the results of various measurements. For each case, tell which digit was "guessed at" by the observer making the measurement:

	MEASUREMENT	UNCERTAIN DIGIT	UNCERTAINTY
a)	125.4 mL	**4**	**10ths**
b)	9.251 m	**1**	**1000ths**
c)	27 cm	**7**	**1s**
d)	425.90 cm	**0**	**10ths**

8. Using the two rulers on the right, read the measurement of the black bar:

Ruler-A: **2.7 cm**

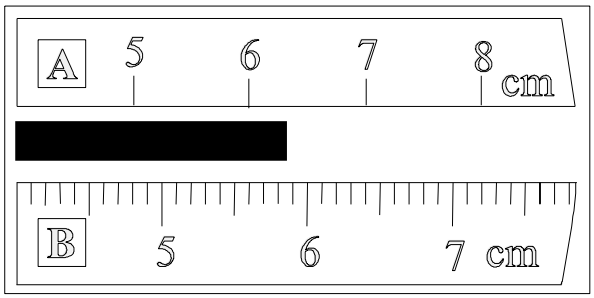
Ruler-B: **2.75 cm**



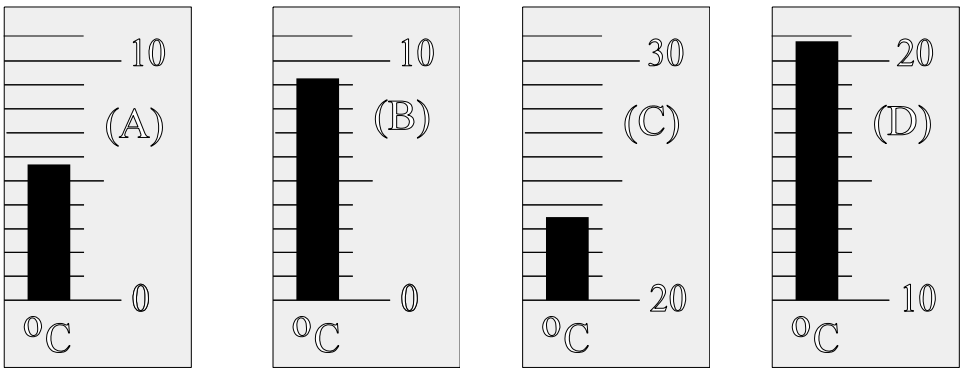
9. Using the two rulers on the right, read the measurement of the black bar:

Ruler-A: **6.4 cm**

Ruler-B: **5.86 cm**



10. The figures below represent a thermometer showing four different thermometer readings. What is the temperature for each reading?

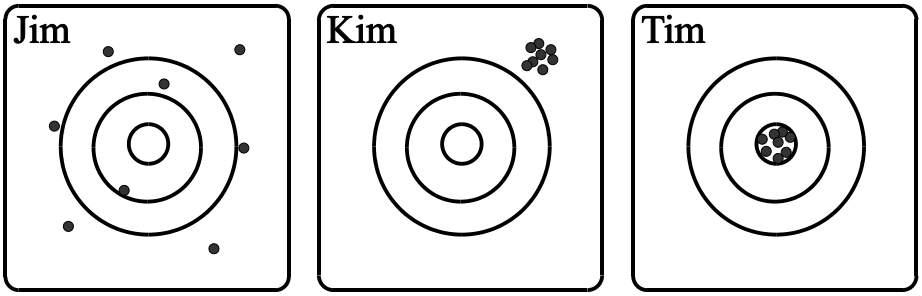


THERMOMETER	READING (˚C)	ESTIMATED DIGIT
A	**5.6 ˚C**	**6**
B	**9.2 ˚C**	**2**
C	**23.5 ˚C**	**5**
D	**20.8 ˚C**	**8**

11. Differentiate between accuracy and precision.

By definition, accuracy means how close a measured value is to the accepted standard value. Precision means how close together a series of measurments are. That is, precision refers to the reproducibility of a series of measurements.

12. Assuming that the following represents target shooting (darts), classify both the precision and the accuracy for each player as GOOD or BAD:



	Jim	Kim	Tim
Precision	**Bad**	**Good**	**Good**
Accuracy	**Bad**	**Bad**	**Good**

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