PhyzSpringboard: Accuracy and Precision

ACCURACY AND PRECISION ARE DIFFERENT

1. A gold coin is measured on a very accurate and precise scale to have a mass of 127.96458 grams.
   - A second scale gives a reading of 128 grams. The second scale is **accurate** but not **precise**.
   - A third scale gives a reading of 135.21568 grams. The third scale is **precise** but not **accurate.**
   - A fourth scale gives a reading of 115 grams. The fourth scale is neither **accurate** nor **precise.**

   a. Based on the examples above, what is the scientific meaning of the term **accuracy**?

   How close the measurement is to the accepted value

   b. Based on the examples above, what is the scientific meaning of the term **precision?**

   How exact the measurement is; how many sig figs the measurement is expressed in.

   c. If you could have either accuracy or precision in making measurements—but not both—which would you choose and why?

   Accuracy: better to be close to the accepted value than to have an exact value far from the accepted value.

PRECISION PUZZLEMENT

2. a. Consider these two measurements: 3,100 m and 0.0031 m. Which value—if either— is more precise and why?

   Both numbers are expressed with equal precision. Each has two significant figures.

   b. Which of these two values—if either—is more precise: ___ 3.1×10^{3} m or ___ 3.1×10^{-3} m ?

   Both numbers are expressed with equal precision. Each has two significant figures.

   c. Which of these two values—if either—is more precise: ___ 0.031 m or ___ 3.1 cm ?

   Both numbers are expressed with equal precision. Each has two significant figures.

   d. Rank the following measurements from most precise (1) to least precise (6).

4 i. 9.23 cm	5 ii. 0.36 A	3 iii. 3,572 g
6 iv. 0.00001 s	1 v. 569,432,000 eV	2 vi. 87,629,000,000 V

   e. What is the **misconception** held by someone who thinks 0.001 m is a more precise value than 12 m ?

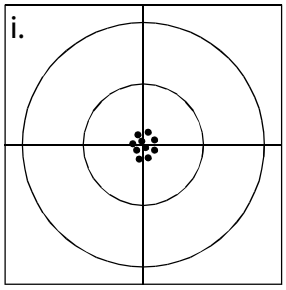
   The misconception that resolution or fineness is the same as precision: that having significant figures in small increment places / low powers of ten (tenths, hundredths, etc.) translates into superior precision.

RANDOM VS. SYSTEMATIC ERROR

2. Consider the target-shooting results shown below. The objective is to hit the center of the target each time. Ten shots were fired through each target. Error prevents the shooter from hitting the target at its center each time. Two types of error affect the results: **random** and **systematic**.

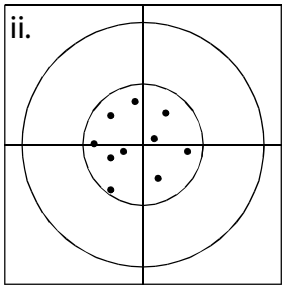
a. Match the correct title to each diagram: Mostly Random Error, Mostly Systematic Error, Random and Systematic Error, Minimal Error.

i.



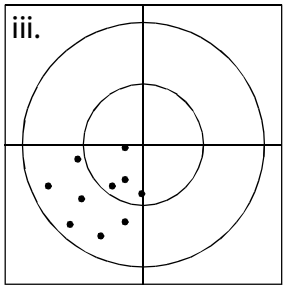
Minimal Error.

ii.



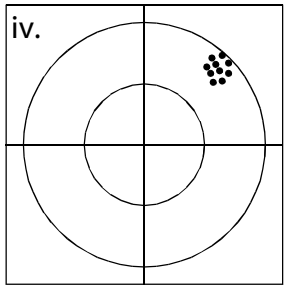
Mostly Random Error.

iii.



Random and Systematic Error.

iv.



Mostly Systematic Error.

b. Distinguish between **random** and **systematic** error.

Random error scatters the data (detracts from *precision*).

Systematic error skews the data (detracts from *accuracy*).

c. Under what conditions can an error-free measurement be made?

None. Error CANNOT be avoided. Mistakes CAN be avoided. Mistakes are not error, they are mistakes. A measurement can be made without mistakes, but no measurement is without error. Wow, that's deep.

3. Consider the odometers of four cars. Car Alpha is a vehicle engineered by the Bureau of Weights and Standards to be precise and accurate; it is free of systematic and random error. Cars Gamma, Lambda, and Theta were recently purchased from Crazy Eddie's Used Car Emporium. Their odometer readings are compared to the readings of Car Alpha as all cars run a 6.0 mile course. The data is listed below.

Car Alpha	1.0	2.0	3.0	4.0	5.0	6.0
Car Gamma	0.9	1.8	2.7	3.6	4.5	5.4
Car Lambda	1.2	2.0	2.7	3.9	5.3	6.1
Car Theta	1.1	2.4	3.6	4.7	6.2	7.5

Diagnose the type of error or errors—random or systematic—that each car (other than Car Alpha) suffers from.

Car Gamma: Systematic Error
Car Lambda: Random Error
Car Theta: Random and Systematic Error