

## Exact Numbers

Which types of numbers are considered “exact?” Below are some general rules. If the number is not included among those listed here, the safest thing is to consider it not exact.

If I find any more exact numbers as we go through the course I will add them to this list. (Also see the handy little precision vs. accuracy table at the end of this document!)

1. Conversions between units **within the English System are exact.**  
e.g.  $12\text{ in} = 1\text{ ft}$  or  $12\text{ in}/1\text{ ft}$  (In this conversion, 12 and 1 are both exact.)
2. Conversions between units **within the Metric System are exact.**  
e.g.  $1\text{ m} = 100\text{ cm}$  or  $1\text{ m}/100\text{ cm}$  (In this conversion, 1 and 100 are both exact.)
3. Conversions **between English and Metric system are generally NOT exact.** Exceptions will be pointed out to you.  
e.g.  $1\text{ in} = 2.54\text{ cm}$  exactly (1 and 2.54 are both exact.)  
e.g.  $454\text{ g} = 1\text{ lb}$  or  $454\text{ g}/1\text{ lb}$  (454 has 3 sig. fig., but 1 is exact.)
4. “**Per**” means out of **exactly one**.  
e.g. 45 miles per hour means  $45\text{ mi} = 1\text{ hr}$  or  $45\text{ mi}/1\text{ hr}$ . (45 has 2 sig. fig. but 1 is exactly one.)
5. “**Percent**” means out of **exactly one hundred**.  
e.g. 25.9% means 25.9 out of exactly 100 or  $25.9/100$  (25.9 has 3 sig. fig., but 100 is exact.)
6. **Counting numbers are exact.** Sometimes it is hard to decide whether a number is a “counting number” or not. In most cases it would be obvious. Ask when in doubt.  
e.g. There are 5 students in the room. (5 would be an exact number because you cannot have a fraction of a student in the room.)  
e.g. subscripts in a formula, and coefficients in a balanced equation, are considered “counting numbers” and are exact
7. **Mathematical constants are exact.** The symbol  $\pi$  is exact; however, the number 3.14 has only three significant figures, while 3.1416 has five. In a mathematical formula, such as  $V = (4/3)\pi r^3$ , or  $\text{P.E.} = \frac{1}{2}mv^2$ , the fractions are exact numbers.
8. **The conversions between Celsius, Fahrenheit, and Kelvin temperatures are exact.** This means the fractions (5/9 or 9/5) and the number 32 are exact. The number 273.15, in the Celsius to Kelvin temperature conversion, is also exact.
9. **Speed of light in a vacuum is exact**, and is equal to 299,792,458 m/s.

Precision	Accuracy
reproducibility	correctness
check by repeating measurements	check by using a different method
poor precision results from poor technique	poor accuracy results from procedural or equipment flaws
poor precision is associated with 'random errors' - error has random sign and varying magnitude. Small errors more likely than large errors.	poor accuracy is associated with 'systematic errors' - error has a reproducible sign and magnitude.