

Astronomy 101 Laboratory Reference Sheet

Significant Figure Rules

1. All non-zero numbers are significant.

2392 has 4 significant figures.

2. Zeroes are significant when surrounded by non-zero numbers.

205 has 3 significant figures.

3. If there is a decimal point, all zeroes following non-zero numbers are significant.

2.5000 has 5 significant figures. 250.0 has 4 significant figures.

4. If there is not a decimal point zeroes following the last non-zero number are not significant.

2500 has 2 significant figures.

5. Zeroes before the first non-zero number are not significant.

00025 has 2 significant figures.

Addition and Subtraction: Round to the least precise decimal place.

$$\begin{array}{r} 101.25 \\ +34.3 \\ \hline 135.55 \\ 135.6 \end{array}$$

← Calculator Answer
← Actual Answer w/ SIGFIGS

Multiplication and Division: Keep only as many digits as the term with the FEWEST number of significant digits.

$$\begin{array}{ccccccc} 23.0 & \times & 1.234 & \times & 1.2 & = & 34.0584 = 34. \\ \uparrow & & \uparrow & & \uparrow & & \uparrow \\ 3 \text{ SIGFIGS} & & 4 \text{ SIGFIGS} & & 2 \text{ SIGFIGS} & & \text{Final Answer} \\ & & & & & & 2 \text{ SIGFIGS} \end{array}$$

Scientific Notation

1. Identify Significant Figures.

239200000 has 4 significant figures.

2. Move the decimal to just behind the first non-zero number.

The decimal point will move 8 places to the left: 2.392

3. The number of places the decimal moved becomes the **Order of Magnitude** - the exponent on the ten.

$$239200000 = 2.392 * 10^8$$

For small numbers, the decimal moves to the right, and the order of magnitude becomes negative.

$$.000002392 = 2.392 * 10^{-6}$$

When adding and subtracting, make sure the numbers have the same order of magnitude.

$$2.45 * 10^4 + 3.28 * 10^4 = 5.73 * 10^4$$

$$2.45 * 10^4 + 8.93 * 10^4 = 11.38 * 10^4 = 1.138 * 10^5$$

$$2.4 * 10^4 + 3.2 * 10^5 = 2.4 * 10^4 + 32 * 10^4 = 34.4 * 10^4 = 3.44 * 10^5$$

When multiplying and dividing, multiply or divide the coefficients, then add the orders of magnitude if multiplying or subtract if dividing.

$$1.4 * 10^3 * 2.2 * 10^4 = (1.4 * 2.2) * 10^7 = 3.1 * 10^7$$

$$1.4 * 10^{-3} * 2.2 * 10^4 = (1.4 * 2.2) * 10^{-3+4} = 3.1 * 10^1$$

$$5.4 * 10^5 \div 2.8 * 10^3 = (5.4 \div 2.8) * 10^{5-3} = 1.9 * 10^2$$

Round your results using appropriate significant figures.

E-notation: Instead of writing a number in scientific notation like $5 * 10^7$, you can use E-notation to replace the 10 with an e, like 5e7. In this case, you do not write the order of magnitude as an exponent, you just write it after the e. This notation is primarily used in computer programming when it's easier to print an 'e' than an exponent.

Scientific Notation and Calculators: Many calculators have an option to type a number in scientific notation. Sometimes this button looks like $\boxed{x10}$, and other times it is written as $\boxed{\text{Exp}}$. It is important to note that the button labeled 'e' is NOT used for scientific notation. The 'e' button is a scientific constant, and is not used in scientific notation.

REMEMBER TO USE SIGNIFICANT FIGURES

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Units and Dimensions

A **dimension** is a physical quantity you can measure. Some common dimensions are:

Length/Distance	Angles
Area	Energy
Volume	Temperature
Time	Mass

Dimensions are measured by **units**. The same dimension can be measured by different units. For example, length can be measured in meters, feet, miles, lightyears, parsecs, furlongs, AU, angstroms, and many other units.

In order to add together two quantities, they must have the same units. If they do not have the same units, you must **convert** one quantity to the units of the other quantity. For example, to convert a number from miles to kilometers:

$$20 \text{ miles} * \frac{1.61 \text{ kilometers}}{1 \text{ mile}} = 32.2 \text{ kilometers}$$

Some dimensions are combinations of other dimensions. For example, velocity = $\frac{\text{distance}}{\text{time}}$.

Ratios

When comparing the sizes of two numbers with the same dimension, take one number and divide it by the other one (make sure both numbers are in the **same units**).

$\frac{\text{"Big"}} = How many times larger the big number is than the small number.$

$\frac{\text{"Small"}} = How many times smaller the small number is than the big number.$

For example, 2.8 miles is 1232 times longer than 12 feet:

$$\frac{2.8 \text{ miles}}{12 \text{ feet}} * \frac{5280 \text{ feet}}{1 \text{ mile}} = \frac{14784 \text{ feet}}{12 \text{ feet}} = 1232$$

Note that the result does not have any units.

When using scientific notation, simply follow the rules for division with scientific notation (listed on the other side of this sheet).

$$\begin{aligned} \frac{2.392 * 10^8 \text{ sec}}{3.45 * 10^3 \text{ sec}} &= \frac{2.392}{3.45} * \frac{10^8}{10^3} = 0.693 * 10^{8-3} = \\ &= 0.693 * 10^5 = 6.93 * 10^4 \end{aligned}$$

Trigonometry

Finding angular size in arcminutes of an object in a picture:

1. Find the object's size in pixels using the pixel ruler.
2. Find the picture's size in pixels using the pixel ruler.
3. Find the picture's angular size in arcminutes. This is usually given in the text as the **Field of View**.
4. Convert the object's pixel size to angular size using the following formula:

$$\text{Object}_{\text{Arcmin}} = \text{Object}_{\text{pixels}} * \frac{\text{Picture}_{\text{Arcmin}}}{\text{Picture}_{\text{pixels}}}$$

Often, you will then need to convert this number from arcminutes into **Radians**:

$$\text{Object}_{\text{Rad}} = \text{Object}_{\text{Arcmin}} * \frac{60 \text{ arcsec}}{1 \text{ arcmin}} * \frac{1 \text{ radian}}{206265 \text{ arcsec}}$$

Finding actual size of an object from its angular size in radians:

$$\text{Actual Size} = \text{Distance} * \text{Angular Size}_{\text{Radians}}$$

The object's actual size will have the same units as whatever units you use for the distance. For example, if the distance is in parsecs, the actual size will be in parsecs. If the distance is in lightyears, the actual size will be in lightyears. **MAKE SURE TO USE THE ANGULAR SIZE IN RADIANS, NOT ARCMIN.**

Finding distance to an object from its actual size and angular size:

Alternatively, if you know an object's actual size and its angular size, you can find its distance.

$$\text{Distance} = \frac{\text{ActualSize}}{\text{AngularSize}_{\text{Radians}}}$$

Again, your distance will have the same units as your actual size. So if the actual size is in parsecs, the distance will be in parsecs. **MAKE SURE TO USE THE ANGULAR SIZE IN RADIANS.**

REMEMBER TO USE SIGNIFICANT FIGURES