

Pre-lab 7: Metric Prefixes

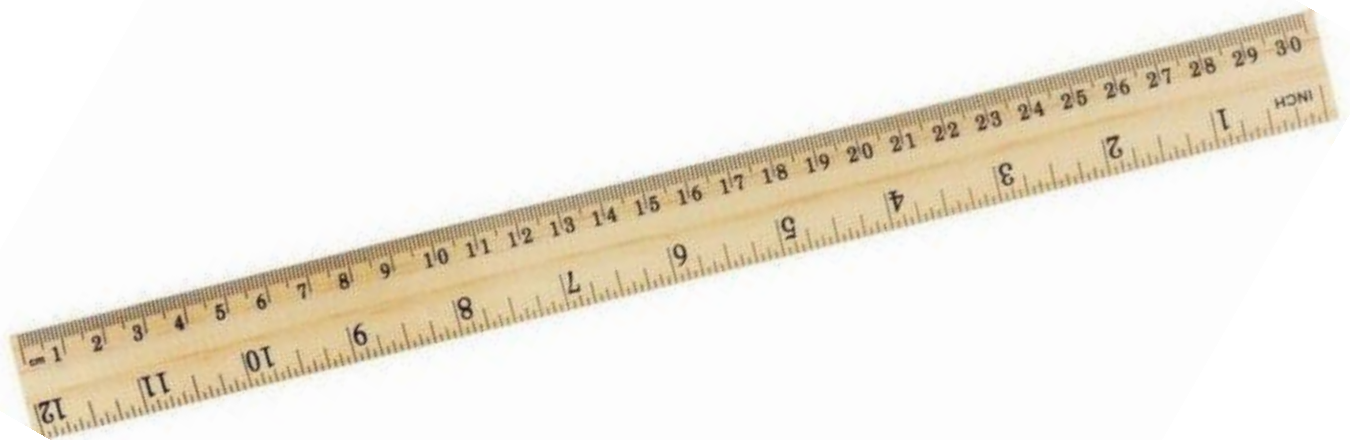
AST 105

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You're probably familiar with the other side of the ruler, which uses centimeters and millimeters rather than inches.

You might also be familiar with how those units are part of the **metric system**, whose units of length are based on the **meter**.

One centimeter is one hundredth of a meter, and one millimeter is one thousandth of a meter.

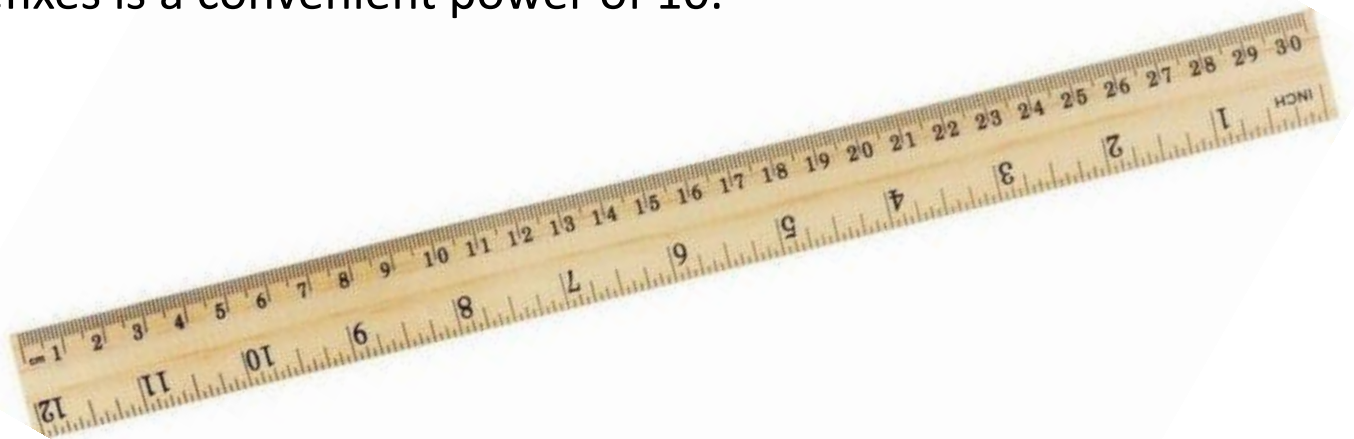


Similarly, a kilometer is a thousand meters.

With centimeters and millimeters and kilometers, we have a prefix at the front that tells us what fraction (or multiple) of a meter we're dealing with.

There are other prefixes available as well: for example a decimeter (dm) is one tenth of a meter, and a picometer (pm) is a trillionth of a meter.

Each of these prefixes is a convenient power of 10.



And these prefixes work with other units from the metric system as well. For example:

- A kilogram is 1,000 grams.
- A milliliter is $1/1000$ of a liter.
- A millisecond is $1/1000$ of a second.

These prefixes work with more exotic units that are based in the metric system...

- A newton is a unit of force: the amount of force needed to accelerate a 1-kilogram object by 1 meter per second squared. A kilonewton is 1000 of those.
- A joule is a unit of energy: the amount of energy you spend by applying 1 newton of force over a 1-meter distance. A kilojoule is 1000 joules.
- A watt is a unit of power, equal to one joule per second. A kilowatt is 1000 watts.

...and sometimes get applied to units that aren't part of the metric system:

- A bar is a unit of pressure, roughly equal to the air pressure at sea level on Earth. A millibar is $1/1000$ of a bar.
- An “electron volt” is a unit of energy often used in atomic physics. A kiloelectron volt is 1000 electron volts.
- A parsec is a unit of distance, equal to about 3.26 light years. A kiloparsec is 1000 parsecs.

So let's look at some metric prefixes we're more likely to encounter in astronomy. We'll stick them onto the **meter** for convenience.

Let's start by going big.

A **meter** (m) is a little more than 1 yard: about 3.3 feet.

A **kilometer** (km) is one thousand meters, and a little less than $\frac{2}{3}$ of a mile.

So let's look at some metric prefixes we're more likely to encounter in astronomy. We'll stick them onto the **meter** for convenience.

The next largest metric prefix of interest is *mega-*, abbreviated with a capital M. It means "million."

A megameter (Mm) is one million meters. Earth has a diameter of about 12.7 Mm.

You might see things in Earth's distant history referred to as happening so-many Myr ago.

So let's look at some metric prefixes we're more likely to encounter in astronomy. We'll stick them onto the **meter** for convenience.

Beyond *mega-* we have *giga-* (abbreviated G), which means "billion." A gigameter is 1,000,000,000 meters. Earth is about 150 Gm away from the Sun.

14 GHz (gigahertz) is a frequency of 14 billion times per second.

Earth formed about 4.543 Gyr ago.

You might also have seen the prefixes *kilo-*, *mega-*, and *giga-* regarding computer stuff. Be careful: these prefixes are not the same powers of ten you'd encounter elsewhere.

In the early days of computing, memory was best organized in powers of 2. A single bit can be a 0 or a 1 (two possibilities), and a byte is eight bits ($2^8 = 256$ possibilities).

You can't get 1000 with a power of 2, but you can come close. 2^{10} bytes is 1024 bytes. Computer scientists decided it was close enough to warrant the *kilo-* prefix, so they defined a kilobyte (kB) as 1024 bytes. Similarly, a megabyte (MB) is 1024 kB, and a gigabyte (GB) is 1024 MB.

When you purchase a memory stick or other storage device, the packaging often likes to carefully define its units to use 1000's rather than 1024's, so it looks like you're getting more storage.

All right, let's head toward the small end.

You're hopefully familiar with the prefix *centi-* meaning one hundredth, and *milli-* meaning one thousandth.

100 cm equals 1 m, and 1,000 mm equals 1 m.

All right, let's head toward the small end.

Head even tinier, and we get the metric prefix *micro-*, meaning one millionth (0.000001). Its abbreviation is... hmmm, we've already used "m" for *milli-* and "M" for *mega-*...

The metric prefix *micro-* is abbreviated with a lowercase Greek letter mu: μ . (If you squint, it looks kind of like a stylized M.)

Typical human hairs are 40-100 μm in thickness.

Medication might be measured in μg , though some pharmacies abbreviate "micrograms" as "mcg" to avoid confusion with milligrams.

All right, let's head toward the small end.

Even tinier than a microsomething is a nanosomething. The prefix *nano-* (abbreviated n) refers to a billionth.

Things that are nanometers in size become impossible to see with the typical “lenses and mirrors” microscope that you look into, because they are too small for visible light to interact with easily.

That's as far as we'll go. There are metric prefixes that go smaller than *nano-* and larger than *giga-*, but they're encountered less often, even in astronomy.

While we're at it, though, let's review some common powers of 10 just to make sure everyone's on the same page:

1,000	one thousand		0.001	one thousandth
1,000,000	one million		0.000001	one millionth
1,000,000,000	one billion		0.000000001	one billionth
1,000,000,000,000	one trillion		0.000000000001	one trillionth

Let's look at everything together in one nice convenient reference table: metric prefixes, their abbreviations, their meanings, and what those factors look like as numbers and as powers of ten:

nano-	n	billionth	.000 000 001	10^{-9}
micro-	μ	millionth	.000 001	10^{-6}
milli-	m	thousandth	.001	10^{-3}
(no prefix)		(one)	1	10^0
kilo-	k	thousand	1000	10^3
mega-	M	million	1,000,000	10^6
giga-	G	billion	1,000,000,000	10^9
tera-	T	trillion	1,000,000,000,000	10^{12}