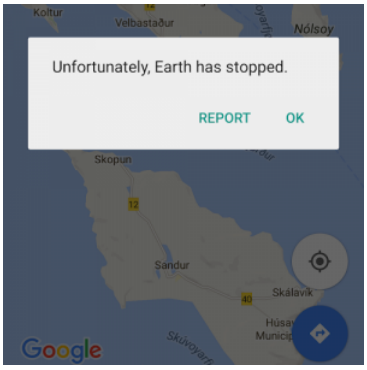
2.8.5: Other Conversions

You may use a calculator in this module as needed.

Converting Measurements of Time



You probably know all of the necessary conversions for time. When we get to units of time larger than weeks, however, we encounter problems because not all months have the same number of days, a year is not exactly 52 weeks, and the time it takes for the Earth to orbit the Sun is not exactly 365 days. Therefore, it doesn't make sense to expect an exact answer to a question like "how many minutes are in one month?" We will have to use our best judgment in situations such as these.

1 min = 60 sec

1 hr = 60 min

1 day (dy) = 24 hr

1 week (wk) = 7 dy

1 year (yr) = 365 dy

? Exercises 2.8.5.1

1. How many minutes is one standard 365-day year?[1]

2. Have you been alive for 1 billion seconds? Is this even possible?

Answer

1. $525,600$min
2. this is roughly 31.7years, which is indeed possible

Converting Rates

? Exercises 2.8.5.1

Usain Bolt holds the world record time for the 100-meter dash, 9.58 seconds.

3. What was his average speed in kilometers per hour?

4. What was his average speed in miles per hour?

Answer

3. 37.6km/hr
4. 23.3mi/hr

The more information we know, the more things we can figure out.

Exercises 2.8.5.1

An F-15 fighter jet can reach a sustained top speed of roughly Mach 2.3; this is 2.3 times the speed of sound, which is 770 miles per hour.[2]

5. What is the jet's top speed in miles per hour?

6. At this speed, how many miles would the jet travel in one minute?

The jet's range at this speed before it runs out of fuel is around 600 miles.

7. If the jet flies 600 miles at top speed, for how many minutes will it fly?

The jet's maximum fuel capacity is 3,475 gallons of fuel.

8. If the jet flies 600 miles and burns 3,475 gallons of fuel, find the jet's fuel efficiency, in miles per gallon.

9. Rewrite the jet's fuel efficiency, in gallons per mile.

10. How many gallons of fuel does the jet consume in one minute?

Answer

5. 1,770 mi/hr
6. 29.5 mi in 1 min
7. 20.3 min
8. 0.17 mi/gal
9. 5.8 gal/mi
10. 171 gal in 1 min

Measurement Prefixes: Larger

Now let's turn our attention to converting units based on their prefixes. We'll start with large units of measure.

tera- (T)	giga- (G)	mega- (M)	kilo- (k)	**[base unit]**
trillion	billion	million	thousand	one
1,000,000,000,000	1,000,000,000	1,000,000	1,000	1
10^{12}	10^{9}	10^{6}	10^{3}	10^{0}

Notice that the powers of these units are multiples of 3, just as with the engineering notation we saw in a previous module. Each prefix is 1,000 times the next smaller prefix, so moving one place in the chart means moving the decimal point three places. Also notice that capitalization is important; megagram (which is also called a metric ton) is Mg with a capital M, but milligram is mg with a lowercase m.

Using computer memory as an example:

1 kilobyte = 1,000 bytes

1 megabyte = 1,000 kilobytes = 1,000,000 bytes

1 gigabyte = $1,000$ megabytes = $1,000,000$ kilobytes, etc.

1 terabyte = $1,000$ gigabytes = $1,000,000$ megabytes, etc.

Note: There can be inconsistencies with different people's understanding of these prefixes with regards to computer memory, which is counted in powers of 2, not 10. Computer engineers originally defined 1 kilobyte as $1,024$ bytes because $2^{10} = 1,024$, which is very close to $1,000$. However, we will consider these prefixes to be powers of $1,000$, not $1,024$. There is an explanation at https://physics.nist.gov/cuu/Units/binary.html.

Exercises 2.8.5.1

11. A $5\frac{1}{4}$ inch floppy disk from the 1980s could store about 100 kB; a $3\frac{1}{2}$ inch floppy disk from the 1990s could store about 1.44 MB. By what factor was the storage capacity increased?

12. How many times greater is the storage capacity of a 2 TB hard drive than a 500 GB hard drive?

13. In an article describing small nuclear reactors that are designed to be retrofitted into coal plants, Dr. Jose Reyes of Oregon State University says "One module will produce 60 megawatts of electricity. That's enough for about 50 thousand homes."[3] How much electricity per home is this?

14. In the same article, Dr. Reyes says "a 60 megawatt module could produce about 60 million gallons of clean water per day using existing technologies in reverse osmosis." What is the rate of watts per gallon?

15. The destructive power of nuclear weapons is measured in kilotons (the equivalent of $1,000$ tons of TNT) or megatons (the equivalent of $1,000,000$ tons of TNT). The first nuclear device ever tested, the US's *Trinity*, was measured at roughly 20 kilotons on July 16, 1945. The largest thermonuclear weapon ever detonated, at 50 megatons, was the USSR's *Tsar Bomba*, on October 31, 1961.[4] (Video of *Tsar Bomba* was declassified almost 60 years later, in August 2020.) How many times more powerful was *Tsar Bomba* than *Trinity*?

Answer

11. the capacity increased by a factor of 14.4

12. 4 times greater

13. $1,200$ megawatts per home

14. 1 watt per gallon

15. $2,500$ times more powerful

Measurement Prefixes: Smaller

Now we'll go in the other direction and look at small units of measure.

[base unit]	milli- (m)	micro- (μ or mc)	nano- (n)	pico (p)
one	thousandth	millionth	billionth	trillionth
1	0.001	0.000001	0.000000001	0.000000000001
10^0	10^{-3}	10^{-6}	10^{-9}	10^{-12}

The symbol for micro- is the Greek letter μ (pronounced “myoo”). Because this character can be difficult to replicate, you may see the letter “u” standing in for “μ” in web-based or plaintext technical articles… or you may see the prefix “mc” instead.

Again, the powers are multiples of 3; each prefix gets smaller by a factor of $\frac{1}{1000}$. The negative exponents can sometime be complicated to work with, and it may help to think about things in reverse.

1 meter = 10^3 millimeters = 10^6 micrometers = 10^9 nanometers = 10^{12} picometers

1 second = 10^3 milliseconds = 10^6 microseconds = 10^9 nanoseconds = 10^{12} picoseconds

…and so on.

See https://physics.nist.gov/cuu/Units/prefixes.html for a list of more prefixes.

? Exercises 2.8.5.1

16. An article about network latency compares the following latency times: “So a 10 Mbps link adds 0.4 milliseconds to the RTT, a 100 Mbps link 0.04 ms and a 1 Gbps link just 4 microseconds.”[5] Rewrite these times so that they are all in terms of milliseconds, then rewrite them in terms of microseconds.

17. The wavelength of red light is around 700 nm. Infrared radiation has a wavelength of approximately 10 μm.[6] Find the ratio of these wavelengths.

18. Nuclear radiation is measured in units called Sieverts, but because this unit is too large to be practical when discussing people’s exposure to radiation, milliSieverts and microSieverts are more commonly used. In 1986, workers cleaning up the Chernobyl disaster were exposed to an estimated dose of 250 mSv.[7] A typical chest x-ray exposes a person to 100 μSv.[8] How many chest x-rays’ worth of radiation were the workers exposed to?

Answer

16. 0.4 ms, 0.04 ms, 0.004 ms; 400 μs, 40 μs, 4 μs the ratio of the wavelengths of red and infrared is 7 to 100;

17. the ratio of the wavelengths of infrared and red is around 14 to 1

18. this is equivalent to 2,500 chest x-rays

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1. If you're familiar with the musical *Rent*, then you already know the answer. ↵
2. My sources for the following set of questions are a combination of former students in the Air National Guard and people who sound like they know what they're talking about on the internet, particularly in this Quora discussion. ↵
3. https://www.kgw.com/article/news/local/oregon-company-get-approval-to-build-nuclear-power-plants/283-7b26b8cd-12d5-4116-928a-065731f7a0f6 ↵
4. https://en.Wikipedia.org/wiki/Nuclear_weapon_yield ↵
5. https://www.noction.com/blog/network-latency-effect-on-application-performance ↵
6. http://labman.phys.utk.edu/phys222core/modules/m6/The%20EM%20spectrum.html ↵
7. https://en.Wikipedia.org/wiki/Chernobyl_disaster ↵
8. https://www.cancer.org/treatment/understanding-your-diagnosis/tests/understanding-radiation-risk-from-imaging-tests.html ↵