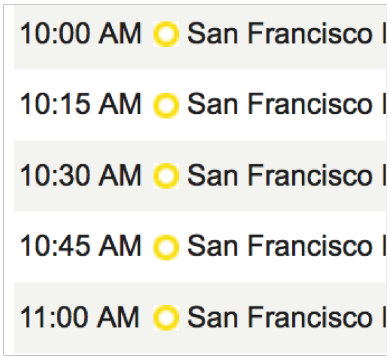
Frequency and Waves Practice

Exercises your knowledge of prefixes and proportional reasoning as well as period, frequency and wavelength.

Frequency and Hertz

Here is the mid-day BART schedule at Orinda Station for the inbound direction



If you just miss a train, you have 15 minutes to wait until the next one.

We say, “the time between trains if 15 minutes,” or the “the period is 15 minutes.”

In equations we say

$P = 15$ minutes

From your perspective as a BART customer, larger P is worse, and smaller P is better, because your average wait time if you arrive at the platform at random is $P/2$.

We also say, “there is a train every 15 minutes,” or there are “four trains per hour.”

The “per” in that statement says that some division is going on, just like in “miles per hour.”

These two concepts are so similar in everyday language that it is sometimes hard to distinguish them, but mathematically, they are obviously different:

contrast $f = \frac{1}{P} = \frac{1\text{ train}}{15\text{ minutes}} = \frac{4\text{ trains}}{\text{hour}}$ with $P = 15$ minutes

f is called the frequency. In the most common scientific units, times are measured in seconds, so for this problem we could convert to:

$$f = \frac{1\ \text{train}}{15\ \text{minutes}} = \frac{1\ \text{train}}{900\ \text{seconds}} = 0.0011\ \frac{\text{trains}}{\text{second}} = 0.0011\ \frac{1}{\text{second}}$$

It is very common to leave off the unit for whatever you are counting. So in the last step, I have dropped the “trains” in the numerator.

Finally, one more step. It is so common to have $\frac{1}{\text{second}}$ show up in a quantity, that it has its own name, “Hertz”, abbreviated Hz. Hertz was a late 19th century physicist who proved the existence of electromagnetic waves.

Practice Problem 1

The maximum number of take-offs using a single runway at SFO is 40 planes per hour. What is this in Hertz?

Practice Problem 2

iMac Pro Model	Max. DRAM	User-Installable Slot	AASP-Installable Slot
iMac Pro (2017)	128GB	None	2666MHz DDR4 ECC

Above are the specs for the memory in an iMac Pro. The frequency quoted is the frequency at which bytes (8 bits) can be read out of memory. 2666 MHz is a frequency. Convert it to a period using the relationship between f and P, which you first have to solve for P.

Express this period in some convenient units (milliseconds, microseconds, nanoseconds, picoseconds?).

If that is how long it takes to read out one byte, and one byte is 8 bits, how long does it take to read out each bit? (This is just dividing the time by 8).

The Speed of Light

In class we showed that $c = \lambda f$. λ is the symbol usually used for "wavelength."

The speed of light is perfectly constant regardless of the frequency or the wavelength!

Practice Problem 3

Google for the wavelength of some type of electromagnetic radiation that you have heard of (microwaves, ultraviolet, radio waves, X-rays, gamma rays, red light, green light, blue light, etc.).

Using $c = 3 \times 10^8$ m/s and some rearrangement of $c = \lambda f$, convert that to a wavelength to a frequency.

Practice Problem 4

Google for the frequency of some other type of electromagnetic radiation.

Convert that frequency to a wavelength.

Practice Problem 5 (Proportional Reasoning)

$c = \lambda f$ can be rearranged to $\lambda = c/f$, or to $f = c/\lambda$. If some frequency of electromagnetic radiation has wavelength 3m, and then the frequency is doubled, what is the new wavelength?

Practice Problem 6 (Proportional Reasoning)

If some wavelength of light has frequency 600 THz (that's Terra Hertz), and the wavelength is doubled, what frequency does it then have?