Milestone: Timekeeping: Homework 8

Due: 3 December 2021

1 Electromagnetic waves

The speed of a wave is always defined via

$$\text{speed} = \frac{\text{distance traveled}}{\text{time taken to travel}}.$$

Algebraic manipulations of this give

$$\text{time taken to travel} = \frac{\text{distance traveled}}{\text{speed}}$$

and

$$\text{distance traveled} = \text{speed} \times \text{time taken to travel}.$$

All electromagnetic waves travel (in a vacuum or air) with speed 3.0×10^8 meters per second.

a) Determine the distance an electromagnetic wave travels in time $2.0\,\text{ms} = 2.0 \times 10^{-3}\,\text{s}$.

b) Determine how long it takes an electromagnetic wave to travel a distance of 100 meters (roughly 100 yards).

2 Finding distance by electromagnetic waves

The way that a system like GPS works is that a GPS transmitter, whose location is known precisely, sends an electromagnetic wave signal to a GPS receiver. The time that it takes the signal to travel is recorded by both the receiver and the transmitter.

a) Suppose that the GPS receiver records that the signal took 0.00020 s to travel. Determine how far the receiver is from the transmitter.

Suppose that the receiver and the transmitter were using quartz clocks to do the timing. The best quartz clock would lose or gain about 0.00001 s per day. Assuming that the clocks were checked about once per day, the actual time taken for the signal to travel could be anywhere between $0.00020\,\text{s} - 0.00001\,\text{s} = 0.00019\,\text{s}$ and $0.00020\,\text{s} + 0.00001\,\text{s} = 0.00021\,\text{s}$.

b) Determine the distance from the transmitter to the receiver for each of these extremes.

c) How big is the range in distances between these extremes?

d) If you wanted to know your position accurately to 1 mile (about 1500 m) in this situation, would the best quartz clock be sufficient? Explain your answer.

3 Frequency of light waves

A red light wave has frequency 4.3×10^{14}Hz.

a) Determine how many crests of the wave enter your eye every second.

b) Determine how many crests of the wave enter your eye every minute.

4 Visible light spectrum

Find a source (something like Wikipedia would be fine in this case) that lists the range of visible light spectrum. Order the basic colors in the spectrum in order of increasing frequency.

5 Electromagnetic spectrum

There exists a large variety of electromagnetic waves, distinguished amongst themselves by their frequencies. Find a source (something like Wikipedia would be fine in this case) that lists the different types of electromagnetic waves across the frequency spectrum. Select three types of electromagnetic wave and describe how each is useful in your everyday life.