1. Light will travel about 300,000 kilometers in 1 second. Here in America we don’t commonly use kilometers, so how many feet will light travel in 1 day? Show all work.

*There are two units to convert: kilometers to feet and seconds to days.*

\[
\begin{align*}
\frac{300,000 \text{ km}}{1 \text{ sec}} &= \frac{300,000 \text{ km} \times \frac{0.621 \text{ miles}}{1 \text{ km}} \times \frac{5280 \text{ feet}}{1 \text{ mile}}}{1 \text{ sec} \times \frac{1 \text{ min}}{60 \text{ sec}} \times \frac{1 \text{ hr}}{60 \text{ min}} \times \frac{1 \text{ day}}{24 \text{ hr}}} = \frac{983,664,000 \text{ ft}}{0.000011574 \text{ day}} \\
&= \frac{9.84 \times 10^8 \text{ ft}}{1.16 \times 10^{-5} \text{ day}} = 8.5 \times 10^{13} \text{ ft/day}
\end{align*}
\]

2. If you haven’t done so already, please write the answer to Question 1 in scientific notation.

\[300,000 \text{ km/s} = 8.5 \times 10^{13} \text{ ft/day}\]

3a. Take a look at your watch and write down the current date and time (record the seconds).

July 02, 2006, 2:42:12 pm

3b. What is the date of your birth? You can make something up if you like, but be accurate to the second.

July 11, 2001, 07:11:05 am

3c. How many seconds have gone by between you the time you were born and the time you read question 3a? Don’t forget that every four years there is an extra day added to the calendar, and the year 2000 was a leap year. Write your final answer using scientific notation with two significant figures. Show all work.

*The solution to this problem involves separating the calculation into manageable parts and then converting units. We know that just less than 5 years have gone by between the two dates. So first let’s figure out how many days have gone by:*

\[5 \text{ yr} \times \frac{365 \text{ day}}{1 \text{ year}} = 1825 \text{ days}\]

*Add one day for leap year in 2004, and subtract 9 days since July 2 is 9 days before July 11.*

\[1825 \text{ days} + 1 \text{ day} - 9 \text{ days} = 1817 \text{ days.}\]

*Now we need to get the hours, minutes, and seconds. Which we can consider separately from the days. Starting with the hours, we convert to calculate that 7 hours elapsed between 7 am and 2 pm. That is, 14 hrs - 07 hrs = 7 hrs. Then 42 - 11 = 31 min, and 12 - 5 = 7 seconds. Now let’s add up this up by converting everything to seconds:*

\[1817 \text{ day} + 7 \text{ hr} + 31 \text{ min} + 7 \text{ sec} = \]
\[
\left( \frac{1817 \text{ day} \times 86400 \text{ sec}}{1 \text{ day}} \right) + \left( 7 \text{ hr} \times \frac{3600 \text{ sec}}{1 \text{ hr}} \right) + \left( 31 \text{ min} \times \frac{60 \text{ sec}}{1 \text{ min}} \right) + 7 \text{ sec} = \\
(156,988,800 \text{ sec}) + (25,200 \text{ sec}) + (1860 \text{ sec}) + 7 \text{ sec} = 157,015,867 \text{ sec} \\
= 1.6 \times 10^8 \text{ sec}
\]

4. Imagine that you were born as a photon at the time of your real birth (3b). If you didn’t bump into anything, how far away would you have gone (in kilometers) by the time you read question 3a?

*Even without a fancy formula, a good method is to make sure the units cancel out in a problem:*

\[
\left( \frac{3.0 \times 10^5 \text{km}}{\text{sec}} \right) \times (1.6 \times 10^8 \text{ sec}) = 4.8 \times 10^{13} \text{ km}
\]

5. The movie *Apollo 13* is 2 hours and 15 minutes long. How many arcminutes does the Moon move over the duration of the movie.

*We need to convert hours to minutes to and then minutes to arc minutes. The movie is 135 min long. Which we need to convert to arc minutes. Let’s make our own conversion factor from minutes to arc minutes. We know the following facts: 1 hour is 60 minutes, 24 hours equal 360 degrees (this is the useful one), and 1 degree is 60 arc minutes (this is the tricky one). So we’ll put time on one side and angular measure on the other:*

\[
24 \text{ hr} = 360^\circ
\]

\[
24 \text{ hr} \times \left( \frac{60 \text{ min}}{1 \text{ hr}} \right) = 360^\circ \times \left( \frac{60 \text{ arcmin}}{1^\circ} \right)
\]

\[
1440 \text{ min} = 21600 \text{ arcmin}
\]

\[
\frac{1440 \text{ min}}{1440} = \frac{21600 \text{ arcmin}}{1440}
\]

\[
1 \text{ min} = 15 \text{ arcmin}
\]

*so the moon has moved 135 min * (15 arc minutes per minute) = 2025 arc minutes in the sky.*

6. The angular size between the towers of the Golden Gate Bridge, as seen from the Campanile, is 3.55°. 6a. What is the separation in arcminutes?

\[
3.55^\circ \times \left( \frac{60'\text{}}{1^\circ} \right) = 213'
\]

6b. *If the towers are separated by 1257 m, then how far away is the bridge from the Campanile?*

*We use the small angle formula:*

\[
\text{distance} = \frac{360^\circ}{2\pi} \times \frac{\text{diameter}}{\text{angular diameter}}
\]
distance = \frac{360^\circ}{2\pi} \times \frac{1257 \text{ m}}{3.55^\circ} = 20,288 \text{ m} = 20.3 \text{ km} = 12.6 \text{ mi}

7. Looking East from the top of Mount Diablo in Walnut Creek you try to see your friend holding up your DVD of *Apollo 13* at the summit of Half Dome in Yosemite National Park, which is about 125 miles away. What is the angular size of the DVD in arc seconds? Hint: you will need to measure, look up, or estimate the size of a DVD.

A DVD is exactly 120 mm diameter, roughly 4 3/4 inches, but anywhere between 4 and 5 inches is a good guess. Convert miles to the units you measured the DVD in, here we’ll use meters for both:

\[
120 \text{ mm} = 120 \text{ mm} \times \left( \frac{1 \text{ m}}{1000 \text{ mm}} \right) = 0.12 \text{ m}
\]

\[
125 \text{ mi} = 125 \text{ mi} \times \left( \frac{1 \times 10^3 \text{ m}}{0.621 \text{ mi}} \right) = 2.0 \times 10^5 \text{ m}
\]

Now we need to use the small angle formula:

\[
\text{angular diameter} = \frac{360^\circ}{2\pi} \times \frac{\text{diameter}}{\text{distance}}
\]

we know from above (problem 5) that $360^\circ$ is 21,600 arc minutes, so let’s plug in values:

\[
\text{angular diameter} = \frac{21,600'}{2\pi} \times \frac{0.12 \text{ m}}{2.0 \times 10^5 \text{ m}} = 0.002'
\]

and the last step is converting arc minutes to arc seconds:

\[
\text{angular diameter} = 0.002' \times \left( \frac{60''}{1'} \right) = 0.12''
\]