The "Galaxy Song" Lab

In this lab you will use the lyrics of Monty Python's Galaxy Song to study some basic facts about the size and shape of our galaxy and our motion within it and to get a sense for the distance that light travels in any given period of time.

Monty Python's Galaxy Song

Whenever life gets you down, Mrs. Brown
And things seem hard or tough
And people are stupid, obnoxious or daft
And you feel that you've had quite eno-o-o-o-o-ough

Just remember that you're standing on a planet that's evolving
And revolving at nine hundred miles an hour
That's orbiting at nineteen miles a second, so it's reckoned
A sun that is the source of all our power
The sun, and you and me, and all the stars that we can see
Are moving at a million miles a day

In an outer spiral arm, at forty thousand miles an hour
Of the galaxy we call the Milky Way
Our galaxy itself contains a hundred billion stars
It's a hundred thousand light-years side to side
It bulges in the middle sixteen thousand light-years thick
But out by us it's just three thousand light-years wide

We're thirty thousand light-years from Galactic Central Point
We go 'round every two hundred million years
And our galaxy is only one of millions of billions
In this amazing and expanding universe

The universe itself keeps on expanding and expanding
In all of the directions it can whiz
As fast as it can go, at the speed of light, you know
Twelve million miles a minute and that's the fastest speed there is
So remember when you're feeling very small and insecure
How amazingly unlikely is your birth
And pray that there's intelligent life somewhere up in space
'Cause there's bugger all down here on Earth

1) What value does the song give for the speed of light? Check whether this is accurate by completing the steps below.
   a) The true speed of light is 3×10^8 meters per second. Convert this to *miles* per second. Show your work and ask your instructor for help if you need it.
   b) In going from m/s to mi/s, did the number get bigger or smaller? Explain why.
   c) Now convert this speed in mi/sec to mi/min. Show your work. Give your answer in both scientific notation and written out fully (e.g. 15 trillion miles per second).
   d) Calculate the error in the value given in the song using the following formula.

$$\text{Error} = \frac{\text{true value - given value}}{\text{true value}}$$

   e) Your answer to (d) is the error as a decimal. Convert it to a percentage by multiplying by 100. How much was the song off as a percentage? Was it accurate or inaccurate, in your opinion?

2) To answer the Questions below, you'll need the formula: Distance = rate x time

   a) To practice using this formula, you will compute how many seconds it takes light to travel various distances. In order to do this, you will have to solve the formula above for the *time*, which is the unknown quantity since you know the *rate* (speed of light) and the *distance* (given below) light needs to travel. Write the new version of the formula down.
   b) Compute the amount of time it takes light to travel each of the following distances. Use scientific notation and a unit in your answers, which should be given in the form of a table.

   Tucson to Phoenix: 115 miles
   Tucson to New York City: 2,000 miles
   Tucson to Beijing, China: 6, 500 miles
   Earth to Mars: 48 million miles
   Sun to Earth: 93 million miles
   Sun to Pluto: 3.5 billion miles

   c) Convert your last three answers to the number of minutes it takes light to travel each distance. Note that these are much nicer numbers to work with and to comprehend.

3) Use the techniques and answers from questions 1 and 2 to answer the following questions. In each case, show your work
   a) How many miles does light travel in one year?

b) How many AU (Earth-Sun distances) does light travel in one year?

4) Now, Convert the words in the song into two pictures of the galaxy DRAWN TO SCALE. One should be face on and one should be edge on. Draw these on either side of a separate sheet of blank paper. You may wish to review the lecture or look up what the components of a galaxy are (bulge, disk, arms). You should:
   a) Specify your scale. Ex: 1mm=5lyr
   b) Label all of the distances in the song
   c) Include velocities as arrows pointing in the direction of movement and label them with a speed.
   d) You should also specify how many times smaller this scale drawing is than the real galaxy. x

5) Calculate how long it takes the sun to orbit the center of the galaxy and compare it to values given in the song.
   a) Note that in making one orbit around the center of the galaxy, the sun traces out a circle. The circumference of that circle is the distance traveled by the sun during one rotation. The formula for the circumference of a circle is $C = 2 \times \pi \times radius$. Calculate the circumference of the sun's orbit around the center of the galaxy in lightyears and then draw the sun's circumference on your picture from (4). You will need to find the radius of this circle in the words to the song.
   b) Use this circumference, one of the velocities given in the song (you'll have to figure out which one!) and your distance = rate x time formula to calculate the amount of time it takes the sun to complete one orbit around the center of the Milky Way. Show your work.
   c) How does this compare to the value given in the song for the time that it takes the sun to complete one orbit? Again, compute the error between your value and the value given in the song and list it as a percentage.