

Homework 1:

The Final Frontier

Due date: February 6 by the end of the lab period.

Assignment

In this homework, you will write a Python program to calculate the *time dilation effect* experienced by a space ship traveling at high velocity. You will submit your answer to Zybooks “Lab 2.17”, which will run simple test cases against your code. If you pass the test cases, **show your TA** to receive credit for the assignment; if you fail a test case, you **must** fix your code until it passes.

Time Dilation

If you were to travel on a space ship at high velocity over a very far distance, the trip would take a shorter amount of time from your perspective than it would from the perspective of the people of Earth. You would age a certain amount of time during the trip (a few months, perhaps), while your friends on Earth would experience and age a much greater amount of time (many years!). This effect is called *time dilation* and is central to Albert Einstein’s theories of relativity, and is an effect we have predicted, observed, and measured in experiments. (So it is *not* theoretical. It is real.)

Suppose that a space ship wants to travel a distance d at a velocity v . Someone on Earth will see the ship travel to the destination over a period of time governed by the “distance formula”: $distance = velocity \times time$. Rearranging this to solve for *time* and substituting our distance and velocity, the Earth observer will experience $time = \frac{d}{v}$ amount of time before the ship arrives at its destination. Note that this solution gives time in **seconds**.

However, someone *on* the ship will experience a **fraction** of that time. The exact fraction can be calculated as the **dilation factor** of the trip:

$$dilation = \sqrt{1 - \frac{v^2}{c^2}}$$

where v is the velocity of the ship and c is the speed of light, $c = 299,792,458 \text{ m/s}$. If we calculate *dilation* and multiply it by the Earth observer’s elapsed time, we calculate the amount of time that passes for the ship’s passenger. As long as v is smaller than c (as long as we do not exceed the speed of light), the dilation factor will be less than 1, and the ship passenger will age **less** than their Earth friend.

Assignment

Write a Python program that does the following:

1. Ask the user to enter the velocity of a space ship, expressed as a **fraction of the speed of light**. For example, entering “0.5” really means $0.5 \times c$.
2. Convert the user’s input into **meters per second** by multiplying it by c (which you will have to write out in your code). Call this value v .
3. Calculate the **dilation factor** at this velocity by using the formula above.
4. Calculate and output how long it takes the space ship to travel to **Proxima Alpha**, the star of the **Alpha Centauri** system, the closest star system to ours; a distance of 7.4740×10^{16} meters. You will output **two values**:
 - (a) The time experienced by an observer on Earth
 - (b) The time experienced by a passenger on the ship

Each of the times you calculate will be in seconds, but you must output those values as **X years and Y days**, where X and Y are whole numbers. (See the example output below.) To do this, take the time in seconds and convert it to **whole days** (assume there are 86,400 seconds in a day). Use modulo and integer division to turn whole days into a number of whole years and a number of “left over” days.

Getting Started

You can complete this assignment in two different ways:

- Using Zybooks’ “Lab 2.17”, you can write your answer in a web browser and then immediately submit it for grading. This is what you do for your Lab and Reading assignments.
- OR, you can write the code using Visual Studio Code (or your favorite editor) on your personal computer. Once VS Code loads, use the “File” menu to select “New File”. Type your program in the editor, then save your code and use the “Play/Run” green arrow button to test your program. When you are ready to submit your solution, select the entire program (Edit menu -> “Select all”) and copy it, then paste it in your web browser to submit it to Lab 2.16 on Zybooks.

Why go through this extra effort? The Zybooks editor is very very simple, and VS Code gives more information about errors in your code and ways to fix them. You may find that helpful.

Hints

It will be difficult to get the correct answer if you start converting between units too early. My advice is to follow this plan:

- After getting input from the user, convert the speed of the ship into meters per second.
- Then calculate the dilation factor as described above.
- Then calculate the first time (the time experienced by an observer on Earth) and leave the answer in **seconds**.
- Then use your previous two answers to find the second time (experienced by a passenger) in **seconds**.
- Then convert the first time (in seconds) to **whole days**. Use this to determine the number of **whole years** and **leftover days** with division and modulo arithmetic.
- Repeat for the second time (in seconds).

Example Output

User input is in *italics*:

```
Enter space ship velocity as a fraction of the speed of light:
```

```
0.8
```

```
Traveling to Wolf 359...
```

```
An observer on Earth ages 9 years, 321 days during the trip.
```

```
A passenger on the ship ages 5 years, 339 days during the trip.
```

Submitting Your Solution

As a reminder, you **must** submit your solution to Zybooks Lab 2.17 and pass all the test cases, **and then** show your accepted solution to the instructor or TA. You will **only** get credit for the assignment when the instructor/TA checks your answer and says that you are finished.