

Practicing Excel Formulae and Kepler's Laws:

Today we will be computing the semi-major axes of planets orbiting another star. In fact, seven planets all orbit TRAPPIST-1 and would all easily fit inside the orbit of Mercury! Despite orbiting so close to their star, many of these planets are actually in the habitable zone due to TRAPPIST-1 being a relatively small and dim star (called a red dwarf).

Astronomers observe the TRAPPIST-1 host star for long periods of time, watching for tiny drops in brightness corresponding to a planet passing in between the star and Earth and blocking a tiny amount of the star's light. The "transit" is periodic – it happens again and again at predictable intervals because the planet orbits its host star with some constant period, P . These measurements of the period of the planet's orbit, along with the mass of the star, help astronomers determine how far each planet orbits from its host star (astronomers can indirectly measure the mass of the host star with techniques that we'll learn about later in the course). Assuming the mass of the star (M_*) is in units of Solar Masses, and the period (P) is in years, the equation below will allow you to solve for the semi-major axis (a) in units of AU:

$$P^2 = \frac{a^3}{M_*}$$

Problems:

1. A spreadsheet template is available on canvas. Please download it and use Microsoft Excel to open the file (not the online version, please). Some data from the TRAPPIST-1 star system is already in the template (green cells). Blue cells require a formula to be written in Excel. How do the given orbital periods of the 7 planets in the TRAPPIST-1 star system compare to the orbital periods of the planets in our solar system?
2. The equation above requires that the orbital period be in units of years. Write a formula in the first blue column that performs this conversion. Notice that each column is meant to walk you through the calculation.
3. Continue writing the Excel formulae to complete each column, using the given data, unit conversions, and Kepler's Laws as needed.
4. Now, let's create a scatter plot of the data. On the horizontal axis, plot the square of the orbital period. Select the cube of the semi-major axis for the vertical axis. (Columns E and F in the template spreadsheet.) Be sure to add axis titles and units to your plot. Add a trendline to the data and display the slope of the line. What do you notice? Is the line a good fit?
5. Let's check your work with a calculation (by hand). If the mass of the star in the TRAPPIST-1 system is 0.0898 Solar Masses and the outermost planet orbits the star every 18.77 days, determine the semi-major axis for this planet (planet TRAPPIST-1 h). Please show your work. Does your check agree with your spreadsheet?