

For the Teacher
Investigate the Speed of a CME
How Fast is that CME Going?

There are two versions of this activity included. *Investigate the Speed of a CME* is an inquiry approach to determining the speed of a CME as it moves through the sun's corona. It requires the students to study the images and develop a procedure to measure speed. *How Fast is that CME Going?* is designed for students who might struggle with the development of such an approach. It provides the student with step by step instructions for determining the speed. The questions in both versions are intended to lead the students to a deeper understanding of the mechanics of a CME.

Both versions will produce differing values from group to group for the velocity. Data will depend on where the student decides to follow the CME and how accurately they can follow the point. However the student will be able to conclude that the CME is moving "very fast".

Below are sample data tables for both sets of images as well as answers to questions.

Set 1

Universal Time	Change in time s	Position km	Change in Position	Average Velocity km/s
17:18	0	0	0	0
17:42	1440	840,000	840,000	580
18:18	2160	1,400,000	560,000	260
18:42	1440	2,240,000	840,000	580
19:42	3600	3,900,000	1,600,000	444

Set 2

Universal Time	Change in time s	Position km	Change in Position	Average Velocity km/s
5:18	0	0	0	0
5:42	1440	700,000	700,000	490
6:18	2160	1,400,000	700,000	324
6:42	1440	2,100,000	700,000	490
7:42	3600	3,100,000	1,000,000	280

How Fast is that CME going

Questions:

1. Show a sample calculation for an average velocity calculation.
 $V = 840,000 \text{ km}/1440 \text{ s} = 580 \text{ km/s}$
2. Are the average velocity values significant? Are you familiar with any object that moves at this velocity?
Yes. If converted to mi/h, values are approximately 1×10^6 . Students will not be familiar with objects at that speed.
3. Select one of the average velocity values and describe what it really means. (For example, a car traveling at 25 mi/h really means that every hour the car travels 25 mi)
580 km/s really means that every second, the solar wind moves 580 km!
4. At your selected velocity, calculate the time it would take the CME material to reach the earth.
 $t = d/v = 150,000,000 \text{ km}/580 \text{ km/s} = 260,000 \text{ s} = 72 \text{ h} = 3 \text{ days}$
5. How consistent were the velocities? If they were changing, what could this mean about the motion of the CME near the sun?
The values varied considerably.

Investigate the Speed of a CME

Questions:

1. Are the average velocity values significant? Are you familiar with any object that moves at this velocity?
The average velocities will be in the 400-500 km/s range. Students will not be familiar with objects at that speed.
2. Select one of the average velocity values and describe what it really means. (For example, a car traveling at 25 mi/h really means that every hour the car travels 25 mi)
580 km/s really means that every second, the solar wind moves 580 km!
3. At your selected average velocity, calculate the time it would take the CME material to reach the earth.
 $t = d/v = 150,000,000 \text{ km}/580 \text{ km/s} = 260,000 \text{ s} = 72 \text{ h} = 3 \text{ days}$
4. How consistent were the velocities within each set? If they were changing, what could this mean about the motion of the CME near the sun?
The values varied considerably.

5. How confident are you with the velocity values you determined on each slide? What are the sources of error within your procedure?
Students should discuss that since the values were not consistent, measuring techniques will play a vital role in experimental accuracy.
6. Was there experimental consistency in the values determined from one set of slides to the other? Would you feel comfortable making a statement concerning the velocity of CME's leaving the sun? Explain.
The average values are close (400/450).
Answer varies
7. The earth is approximately 100 solar diameters from the sun. Estimate the fraction of this distance the leading edge of the CME has reached in the final slides.
1/12th – 1/15th the total distance