

Comets and Coronal Mass Ejections

Student Activity



Your Passion. Our Technology. Student Success.™

7 8 9 10 11 12



TI-Nspire CAS



Investigation



Student



90min

Aim:

The aim of this investigation is to determine the distance a comet moves in a period of time, thus determining the speed of a comet as it approaches the Sun. The comet's speed will also be compared with the speed of a coronal mass ejection (CME) from the Sun. Digital technology and Pythagoras' theorem will be used throughout.

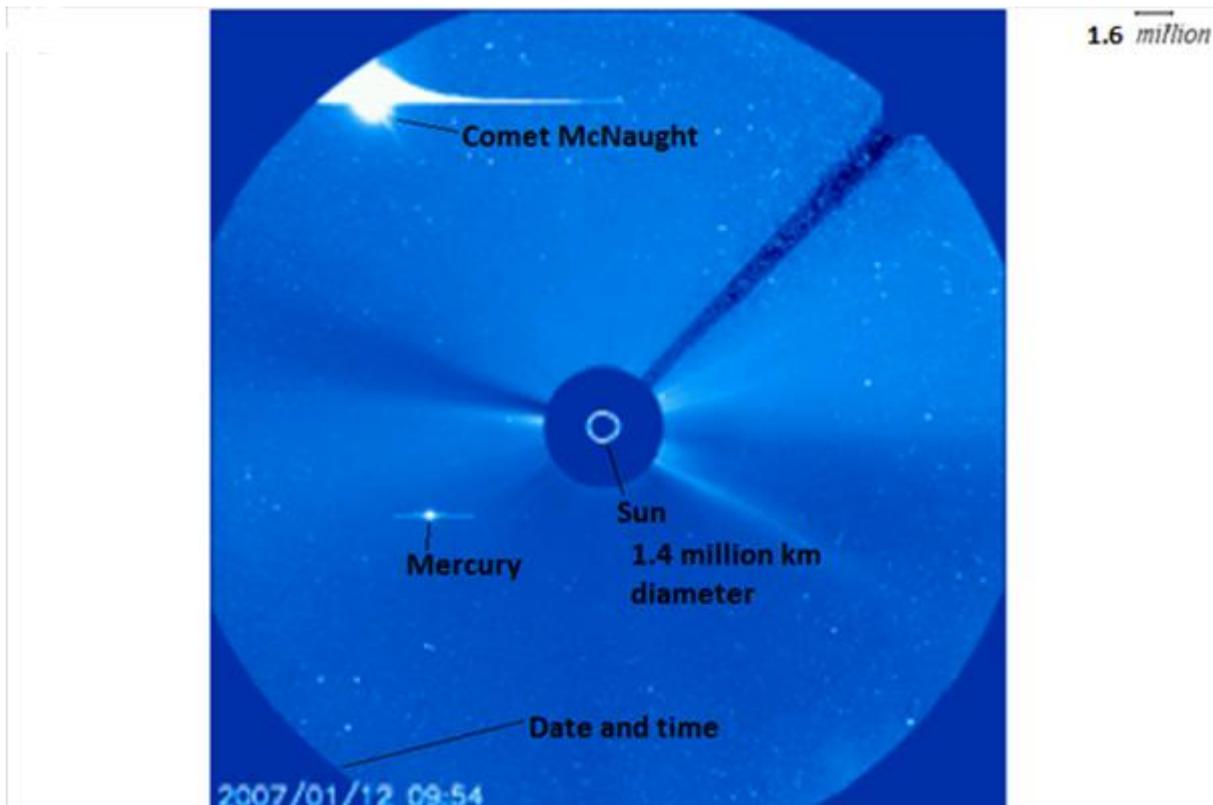
Equipment:

For this activity you will need:

- TI-Nspire CAS (or TI-Nspire)
- TI-Nspire CAS file: Comets and CMEs

Problem Description:

A coronagraph is a telescopic attachment used to block out the Sun's glare so that nearby objects can be resolved. The coronagraph image overleaf was obtained from Solar and Heliospheric Observatory (SOHO) located at <http://soho.nascom.nasa.gov/>. It represents Comet McNaught as it approached the Sun in early January 2007. The comet appears to be approaching the planet Mercury (the bright object in the foreground). The Sun is represented by the white circle in the middle of the coronagraph. It has a diameter of 1,400,000 kilometres. The diameter is used in determining distances travelled by the comet. The speed of the comet can be calculated by using several images and determining how far it moves in a given time interval. The date and time are included in the bottom left hand corner. The dark blue region around the Sun is the area blocked by the coronagraph.



Technology:

This activity requires access to the “Comets and CMEs” TI-Nspire document. This document should be loaded on your device before proceeding.

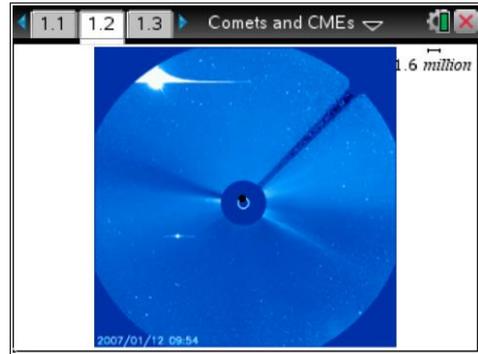
Once the document is on your handheld, press **home** and select **My Documents**. Locate the “Comets and CMEs” document and press **enter** to open.

-  Part of in this investigation requires calculations to be performed. The Scratchpad is a place where calculations can be computed and then discarded. To access the Scratchpad press **home** and select **Scratchpad** (or press **A**). Alternatively, press the  key (this key is not available on a Clickpad).

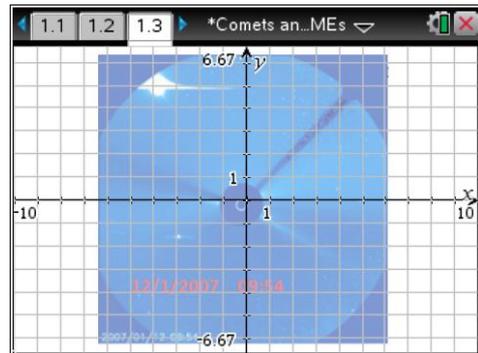


Navigate to page **1.2** (shown opposite). Comet McNaught (top left hand corner) is shown orbiting the Sun and appears to be heading towards Mercury. The small white circle in the centre represents the Sun which has a diameter of 1,400,000 kilometres.

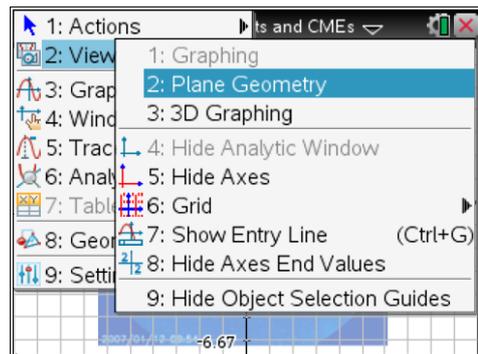
To see the motion of the comet over time scroll quickly through the remaining pages by using the **mouse** or by pressing **ctrl + right arrow**.



Navigate to page **1.3**. This page includes a grid which can be used in conjunction with Cartesian coordinates. The image is ghosted when in this mode. The grid can be switched on and off.



To remove the grid, press **menu > View > Plane Geometry**.
To insert the grid, press **menu > View > Graphing**.

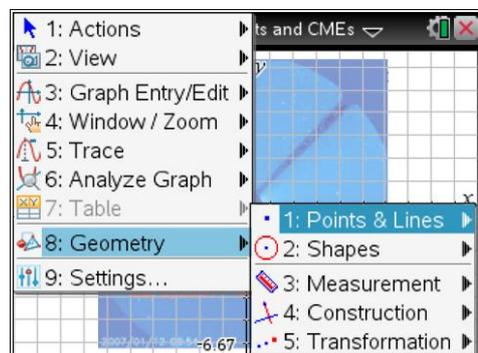


Assigning Cartesian Coordinates

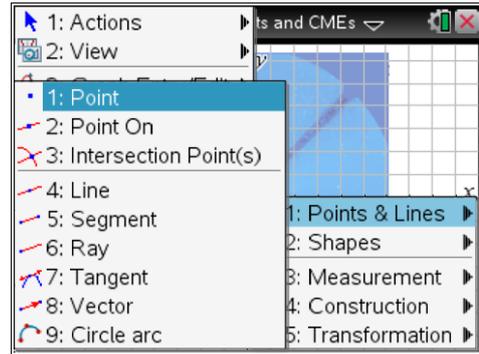
We now want to place points onto the grid to represent the comet as it moves across the screen.

Step 1

- (i) Press **menu > Geometry > Points & Lines**.

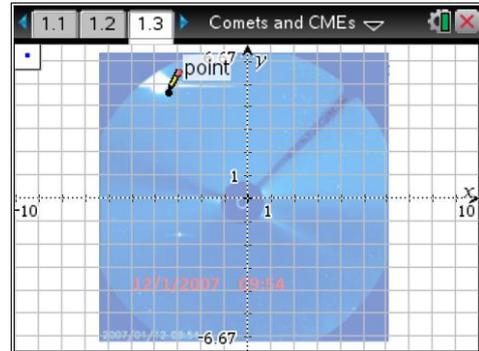


- (ii) Select **Point**.

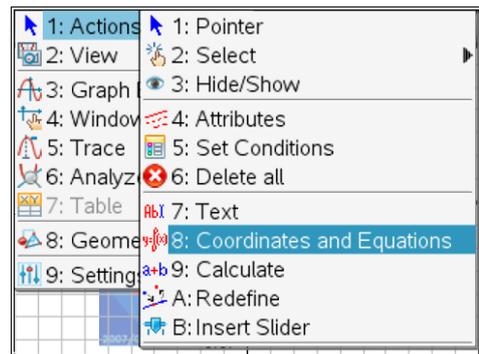


Step 2

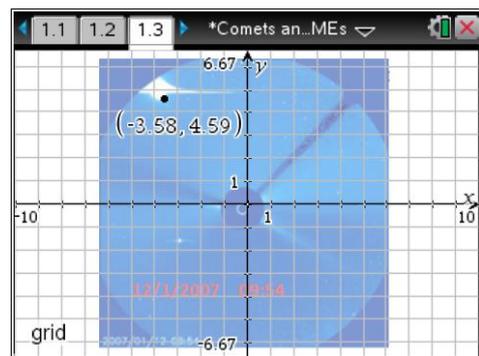
- (i) Use the mouse to place a point at the head of the comet.



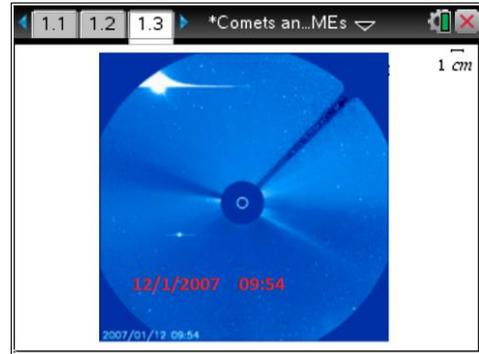
- (ii) Press **menu > Actions > Coordinates and Equations**.



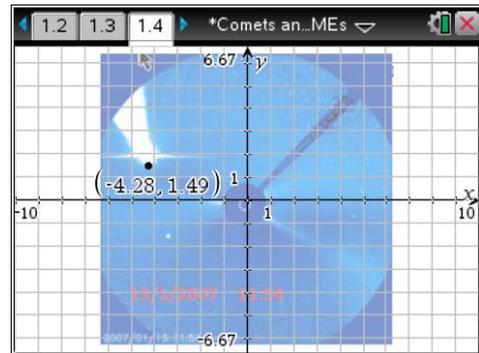
- (iii) Use the mouse to click on the point and the coordinates will appear. For example, these coordinates are **(-3.58, 4.59)**. You can drag the coordinates to a more convenient location if desired.



(iv) Note the date and time in the bottom left hand corner. You may need to turn off the grid in order to accurately read the date and time. The date and time are **12/1/2007** and **09:54**.



(v) Navigate to page **1.4** and place a point at the head of the comet. Determine the Cartesian coordinates, and the date and time. The coordinates are **(-4.28, 1.49)**. The date and time are **13/1/2007** and **11:54**.



Questions

1. Complete the table below for the date, time and coordinates for Comet McNaught.

Image	Date	Time	Coordinates
Screen 1.3	12/1/2007	09:54	(-3.58, 4.59)
Screen 1.4	13/1/2007	11:54	(-4.28, 1.49)
Screen 1.5			
Screen 1.6			

Pythagoras' theorem can be used to determine the distance between two points on the Cartesian plane.

The distance between the points (x_1, y_1) and (x_2, y_2) is:

$$\text{distance} = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$$

From the table above the time interval between screen 1.3 and screen 1.4 is 26 hours. The distance between the coordinates is:

$$d = \sqrt{(-3.84 - -4.28)^2 + (4.7 - 1.49)^2}$$

$d \approx 3.24$ units.

Using the diameter of the Sun as 1,400,000 kilometres; then the width of one square on the grid is approximately equal to two Sun diameters. Therefore one unit on the grid represents 2,800,000 kilometres.

The distance moved by Comet McNaught in 26 hours is 9,072,043 kilometres ($3.240015 \times 2,800,000$).

Since speed = $\frac{\text{distance}}{\text{time}}$, then the speed of Comet McNaught is:

$$= \frac{9,072,043 \text{ kilometres}}{26 \text{ hours}}$$

= 348,925 km/hr, which is 5,815 km/min or 97 km/second.

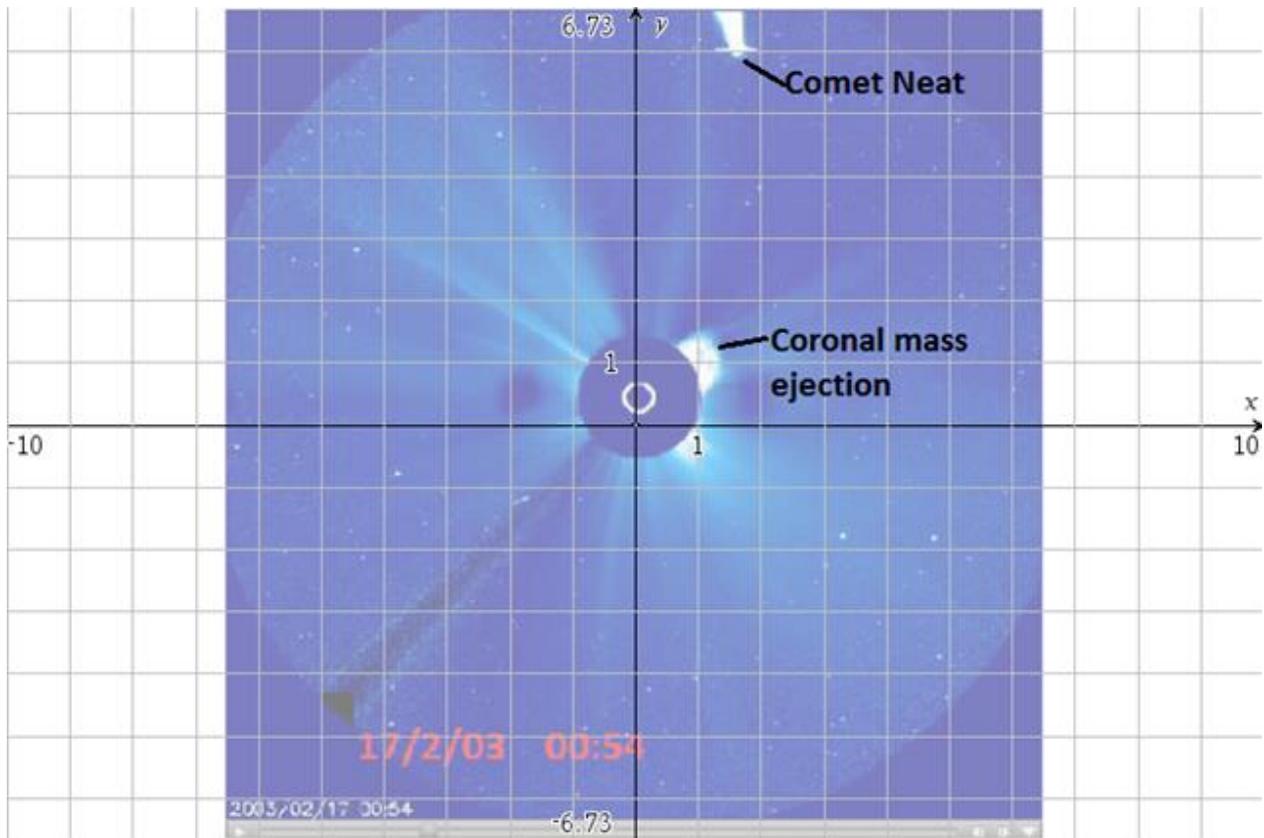
2. Using the Scratchpad, complete the table below for Comet McNaught.

Start and finish time	Time interval (hours)	Distance moved (km)	Speed km/hr	Speed km/min	Speed km/sec
12/1/2007 (09:54) 13/1/2007 (11:54)	26	9,072,043	348,925	5,815	97
13/1/2007 (11:54) 13/1/2007 (21:54)					
13/1/2007 (21:54) 14/1/2007 (10:54)					

3. Use the results from the table to determine the average speed of Comet McNaught. Express the average speed in km/hr, km/min and km/sec.

The following questions relate to Comet Neat (which appeared in February 2003) and a coronal mass ejection (CME) from the Sun. Determine the speed of both the Comet and the coronal mass ejection.

Greater accuracy is obtained when the activity is completed in the computer view mode.



4. Assign coordinates for each of the following screen images of Comet Neat.

Image	Date	Time	Coordinates
Screen 1.8	17/2/03	00:54	
Screen 1.12	17/2/03	05:54	
Screen 1.14	17/2/03	11:54	
Screen 1.18	17/2/03	22:54	

5. Complete the table and determine the speed of Comet Neat.

Start and finish time	Time interval (hours)	Distance moved (km)	Speed km/hr	Speed km/min	Speed km/sec
00:54 05:54					
05:54 11:54					
11:54 22:54					

6. Determine the average speed of Comet Neat. Express the average speed in km/hr, km/min and km/sec.
7. Assign coordinates for each of the following screen images of a coronal mass ejection.

Image	Date	Time	Coordinates
Screen 1.8	17/2/03	00:54	
Screen 1.9	17/2/03	01:54	
Screen 1.10	17/2/03	03:54	
Screen 1.12	17/2/03	05:54	

8. Complete the table and determine the speed of coronal mass ejection.

Start and finish time	Time interval (hours)	Distance moved (km)	Speed km/hr	Speed km/min	Speed km/sec
00:54 01:54					
01:54 03:54					
03:54 05:54					

9. Determine the average speed of the coronal mass ejection. Express the average speed in km/hr, km/min and km/sec.

10. Compare the speed of Comet Neat with the coronal mass ejection.

11. There are additional coronal mass ejections shown up to screen 1.30. Select two screens and determine the speed of this CME. Compare its speed with the speed of the previous CME.

Start and finish time	Time interval (hours)	Distance moved (km)	Speed km/hr	Speed km/min	Speed km/sec