Down to Earth
KS3

Teachers Guide

How long until the event is seen from Earth?

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How long until the event is seen from Earth?

In this activity the students work out how long it takes light to travel from the comet to Earth, and how long after the collision we will see the event.

Objectives

Students will:

- Remember the equation relating distance, time and velocity.
- Use the above equation to find out how long it takes light from comet Tempel 1 to reach the Earth.
- Understand why the impacting spacecraft needs to operate autonomously and not rely on commands sent from scientists on the Earth.

Resources required

- Pens and paper.

Introduction

When the comet Tempel 1 is struck by the impacting spacecraft it will a long way away from the Earth. This means that observers will have to wait for the light to travel from the comet to the Earth before we can see the event.

Question:

1. How long after the impact happens will it be visible from Earth?

Hints

- The comet (and therefore the impact) will be 0.895 Astronomical Units (AU) away from Earth.
- One AU is the average distance between the sun and the Earth, or roughly equal to 92,960,000 miles.
- One mile is equal to 1.6093 km.
- The speed of light in a vacuum is 2.998×10^8 m/sec (299,800,000 m/s).

All that remains is a matter of converting units and using

$$\text{velocity} = \frac{\text{distance}}{\text{time}}$$

The first thing to do is calculate how far away the impact is from Earth in meters

$$0.895 \text{ AU} \times \frac{92{,}960{,}000 \text{ miles}}{1 \text{ AU}} = 83{,}199{,}200 \text{ miles}$$

$$83{,}199{,}200 \text{ miles} \times \frac{1.6093 \text{ km}}{1 \text{ mile}} = 133{,}892{,}472.6 \text{ km}$$

$$133{,}892{,}472.6 \text{ km} \times \frac{1000 \text{ m}}{1 \text{ km}} = 133{,}892{,}472{,}600 \text{ m}$$

And now use this distance and the given speed of light to work out how long it will take for the light from the impact to reach the Earth.

$$133{,}892{,}472{,}600 \text{ m} \times \frac{1 \text{ sec}}{299{,}800{,}000 \text{ m}} = 446.6 \text{ sec}$$

$$446.6 \text{ sec} \times \frac{1 \text{ min}}{60 \text{ sec}} = 7.44 \text{ min}$$

So, it will take 7.44 min (7 minutes, 27 seconds) for the light from the impact to reach Earth.

2. Why is answer to the above question one of the reasons why the impacting spacecraft have to be able to think for itself?

The only way to communicate with the spacecraft from Earth is through radio waves. Radio waves are just another form of light, so they take as long to travel between the site of impact and Earth as the light does.

Extra

Imagine trying to steer the impactor spacecraft from Earth. The impactor cameras notice that the impactor is off course, and send this information to Earth. The message is received 7.44 minutes later, the operator has to make a decision to adjust (say 1 minute

think time?) then the operator's message takes 7.44 minutes to reach the spacecraft. Total elapsed time is around 16 minutes before a course adjustment can begin. By that time, it may be too late to correct, and any correction that the operator came up with may be wrong that much later anyway.

So, it's very important that the impactor spacecraft be able to make its own decisions about course corrections. This is especially true if a decision has to be made anywhere within 15 minutes of impact. Once the impactor is that close, it's too late for any instructions from Earth to do any good!

For comparison, try these questions as well.

As for the questions for comparison, use the distance you calculated and the given speeds to work out the travel times:

3. How long would it take to travel the distance between the comet at impact and Earth if you were: Flying in a jet at around 300 miles per hour (480 kilometers/hour)?

$$133{,}892{,}472.6 \text{ km} \times \frac{1 \text{ hour}}{480 \text{ km}} = 278{,}943 \text{ hours}$$

$$278{,}943 \text{ hours} \times \frac{1 \text{ day}}{24 \text{ hours}} \times \frac{1 \text{ year}}{365 \text{ days}} = 32 \text{ years}$$

4. How long would it take to travel the distance between the comet at impact and Earth if you were: Driving in a car at 65 miles per hour (105 kilometers/hour)?

$$133{,}892{,}472.6 \text{ km} \times \frac{1 \text{ hour}}{105 \text{ km}} = 1{,}275{,}166 \text{ hours}$$

$$1{,}275{,}166 \text{ hours} \times \frac{1 \text{ day}}{24 \text{ hours}} \times \frac{1 \text{ year}}{365 \text{ days}} = 146 \text{ years}$$

5. How long would it take to travel the distance between the comet at impact and Earth if you were: Riding a horse at around 8 miles per hour (13 kilometers/hour)?

$$133{,}892{,}472.6 \text{ km} \times \frac{1 \text{ hour}}{13 \text{ km}} = 10{,}299{,}420 \text{ hours}$$

$$10{,}299{,}420 \text{ hours} \times \frac{1 \text{ day}}{24 \text{ hours}} \times \frac{1 \text{ year}}{365 \text{ days}} = 1{,}176 \text{ years}$$

6. How long would it take to travel the distance between the comet at impact and Earth if you were: Taking a casual walk at around 30 feet per minute (0.5 kilometers/hour)?

$$133{,}892{,}472.6 \text{ km} \times \frac{1 \text{ hour}}{0.5 \text{ km}} = 267{,}784{,}945 \text{ hours}$$

$$267{,}784{,}945 \text{ hours} \times \frac{1 \text{ day}}{24 \text{ hours}} \times \frac{1 \text{ year}}{365 \text{ days}} = 30{,}569 \text{ years}$$