Activity 9

Communication Through Space

GOALS
In this activity you will:
• Calculate time delays in radio communications.
• Express distances in light travel-time.
• Solve distance-rate-time problems with the speed of light.

What Do You Think?
In 1865, Jules Verne wrote *From the Earth to the Moon*. In this book, a team of three astronauts were shot to the Moon from a cannon in Florida. They returned by landing in the ocean. Verne correctly anticipated many of the details of the Apollo missions.

• How well do you think *Star Trek* predicts the future?

Record your ideas about this question in your *Active Physics* log. Be prepared to discuss your responses with your small group and with your class.
Patterns and Predictions

For You To Do

1. Alexander Graham Bell’s grandson suggested a simple way to talk to Europe long-distance. He recommended placing a long air tube across the bottom of the Atlantic Ocean. He believed that if someone spoke into one end of the tube, someone else at the other end would hear what was said.

   a) Do you think this is practical? Give reasons for your answer.
   b) If the sound could be heard in Europe, how long would it take to send a message? (Hint: The distance to Europe is about 5000 km, and the speed of sound is about 340 m/s.)
   c) Compare this time with the time to communicate with extraterrestrials in the next galaxy using light. The nearest galaxy is Andromeda, which is about two million light-years away. (It takes light about two million years to get from Earth to Andromeda.)

2. The highest speed ever observed is the speed of light, \(3.0 \times 10^8\) m/s. In addition, a basic idea of Einstein’s Theory of Relativity is that no material body can move faster than light. Radio waves also travel at the speed of light. If Einstein is correct, there are serious limitations on communication with extraterrestrials. Look at the table of distances below. These are distances from the Earth.

<table>
<thead>
<tr>
<th>Destination</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>to the Sun</td>
<td>(1.5 \times 10^{11}) m</td>
</tr>
<tr>
<td>to Jupiter</td>
<td>(8 \times 10^{11}) m</td>
</tr>
<tr>
<td>to Pluto</td>
<td>(6 \times 10^{12}) m</td>
</tr>
<tr>
<td>to the nearest star</td>
<td>(4 \times 10^{16}) m</td>
</tr>
<tr>
<td>to the center of our galaxy</td>
<td>(2.2 \times 10^{20}) m</td>
</tr>
<tr>
<td>to the Andromeda galaxy</td>
<td>(2.1 \times 10^{22}) m</td>
</tr>
<tr>
<td>to the edge of the observable universe</td>
<td>(1.5 \times 10^{26}) m</td>
</tr>
</tbody>
</table>

   a) How long would it take to send a message using radio waves to each place?
   b) How long would it take to send this message and get an answer back?
3. A real-life problem occurred when the Voyager spacecraft was passing the outer planets. NASA sent instructions to the spacecraft but had to wait a long time to find out what happened. The ship had to receive the instructions, take data, and send the data back home.
   a) If the spacecraft was at Jupiter, how long would it take for the message to travel back-and-forth?
   b) If this spacecraft was at Pluto, how long would it take for the message to travel back-and-forth?

4. Make a time-line of Earth history. For the scale of your time-line, make six evenly spaced marks.
   a) Label the time-line like the one shown.

   
   ![Time-line](image)

   b) On your time-line, label interesting events in Earth’s history that occurred during these times. Possibilities include the end of the last Ice Age (10,000 years ago), the evolution of the modern horse (50 million years ago), the evolution of humans (3 million years ago), the Iron Age (1000 BC), the Stone Age (8000 BC), the Middle Ages in Europe (13th century), the beginning of civilization (3000 BC), and the spread of mammals over the Earth (50 million years ago). (Dates given are approximations.)

5. Many scientists believe that intelligent life would most likely be thousands or millions of light-years away.
   a) How would this affect two-way communication?
   b) If you asked a question, how long would it be before a response came back? Would you be able to receive the response?
   c) What questions would you ask? (Note: Think about the distances involved.)
   d) What kind of answers might you expect?
   e) What changes have occurred on Earth over this time period?
   f) What changes would you expect on Earth before the answer came?
   g) Is two-way communication possible over such distances? Is it practical? Is it likely?
Patterns and Predictions

Reflecting on the Activity and the Challenge

This activity helped you to understand how much time it would take for a light signal to travel from Earth to other places in the solar system, the galaxy, or the edge of the universe. There are many reasons why contact with another life form on another planet would be valuable. You may wish to consider the merits of scientific proposals that seek to communicate with other life forms. You will want to consider whether the proposals take into account the difficulties of sustained communication. You will have to consider the type of communication expected and whether the proposal understands that a response to the simplest question to a life form near the nearest star would take at least six years. If a proposal states that it can communicate faster than the speed of light, they would have to explain how this would be possible since no technique is now known that permits this.

Physics To Go

1. a) The speed of sound is about 340 m/s in air. You and another student take gongs outside about 200 m apart. You hit the gong. After hearing the sound of your gong, the other student hits the other gong. How long is it before you hear the sound of the other gong?
   b) How is this experiment similar to the problem of communicating with extraterrestrial life?

2. a) If extraterrestrial life is probably 1000 light-years away, would it be within this galaxy?
   b) If extraterrestrial life is likely probably several million light-years away, would that be within this galaxy? Could it be in the Andromeda galaxy? (Note: This galaxy has over 100 billion stars.)

3. a) The Moon is $3.8 \times 10^8$ m from the Earth. How long does it take a radio wave to travel from the Moon to the Earth?
   b) The Sun is $1.5 \times 10^{11}$ m from the Earth. How long does it take a light wave to travel from the Sun to the Earth?
   c) Pluto is about $6 \times 10^{12}$ m from the Sun. How long does it take a light wave to travel from the Sun to Pluto?
   d) The nearest star is 4.3 light-years away from Earth. How
long does it take a radio wave to travel from Earth to the nearest star?

e) This galaxy is about 100,000 light-years across. How long does it take light to go all the way across our galaxy?

f) The nearest galaxy is more than a million light-years away. How long does it take light to reach us from this galaxy?

g) The universe is about 15 billion light-years across. How long does it take light to cross the universe?

4. a) In *Star Trek*, the spaceship can move at “warp speed.” This speed is faster than the speed of light. How is warp speed important for space travel?

b) Do you think “warp drive” is likely to be developed? Is it possible? Explain your answers.

5. Suppose your job is to make a plan to send people in space ships to explore nearby galaxies. How would the distances in space affect your plan?

6. a) How would you choose a language for communication with extraterrestrials?

b) Many scientists suggest that a good starting point is to describe the periodic table of the elements. Do you agree? Explain your answer.

c) Is there any evidence that extraterrestrials would observe the same elements, with the same properties, that you observe? Tell what the evidence is.

d) Do you think another advanced civilization would have already discovered the periodic table? Tell why or why not.

e) How would you start to create a language?

f) How would you begin communication?

7. a) Suppose that intelligent extraterrestrial beings exist. Suppose that you are able to communicate with them. Why would you want to?

b) Should you be afraid of extraterrestrial beings?

c) Is it more likely that they would help Earth or enslave Earth? (Note: Consider the distances involved.)
Patterns and Predictions

8. a) What is known of the Earth of 2000 years ago?
   b) It takes 2000 years for a spaceship to travel to a star. When the travelers arrive at the star, would their information about the Earth be up-to-date? Explain why or why not.
   c) If the trip to another star took 10,000 years, would such a trip be worthwhile? Explain why or why not.

9. A record was sent into space in an effort to communicate with extraterrestrials.
   a) If you were on the team designing the record, what music would you include?
   b) What photographs would you include?
   c) What drawings would you include?
   d) Have you fairly represented the majority of the world with your choices?

10. a) Make a list of movies, books, and TV shows that involve trips to other parts of the galaxy or extraterrestrials visiting the Earth.
   b) Very briefly describe the plot of the story.
   c) How accurately is science represented?

Stretching Exercises

1. Read the Carl Sagan book, Contact, or watch the movie. What features of the book and movie have you considered in this chapter? What features have been ignored?

2. Look up the messages that were placed on the Pioneer and Voyager spacecraft. Make a report to the class on how this plaque communicated information about humans.