**News Flash:** **Faster Than Light!**  Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Watch Minute Physics: Faster Than Light Neutrinos (mayb**e) <http://www.youtube.com/watch?v=mT-mCQY2XBE>

Note to teachers: This activity combines two of the original *Process of Science* documents that are found in 1.2 Additional Materials on the DVD but not in the booklet. They are “1.2.2Science in the News - Faster Than Light” and “1.2.4 Case Study - Faster Than Light”.

Scientists working on the Oscillation Project with Emulsion tRacking Apparatus (OPERA) experiment have released data suggesting that neutrinos travel faster than light.

Researchers used a beam of neutrinos prepared at CERN and sent through 732 km of the Earth’s crust to detectors in Gran Sasso, Italy. The detectors measured precisely when and where the neutrinos arrived, allowing the speed of the neutrinos to be calculated. Since the results contradict Einstein’s Special Theory of Relativity and commonly accepted results from other experiments, the researchers were sure that something was wrong with their measurements. When, after spending a year going through the data and their procedure the researchers were still at a loss to explain the results, they published a paper appealing to the scientific community for help.

News about the FTL neutrinos spread across the internet and became a huge event. A live webcast from the CERN auditorium was viewed around the world as researchers and interested people tried to debunk the data. One of the first criticisms levelled at the experiment centred on the size of the neutrino pulses used. The experiment was repeated with smaller pulses - and got the same results. Another experiment based at Gran Sasso, ICARUS, set out to measure the beam of neutrinos and determined that they were travelling at less than the speed of light.

1. Were the neutrinos going faster than light? You have ten fact cards in front of you. All the cards contain true information, most of which is needed to fully answer the question.

Note to teachers: The original exercise with the fact cards has the teacher give only one card to each student. The students then they need to trade cards with other students until they have all ten. This is a good way to get younger students up and moving, but may not be as useful with physics students. I prefer to give each group all ten of the facts at once. The facts have a letter associated to make discussions about ordering the information easier. This activity is great for encouraging students to write clearly and concisely.

1. Some of the information may be irrelevant. Which cards would you eliminate and why?

Students will often write everything that they know about a topic in the hopes that the right answer will be in there somewhere. Irrelevant information clouds the explanation and suggests that the writer doesn’t really understand the question. Students might want to consider eliminating some or all of the following.

**E: OPERA was designed to study how neutrinos change form while travelling**. Changing form is not expected to change speed and so this information is irrelevant.

**H: Neutrinos do not interact very strongly with matter, making them hard to detect.** The physicists may have been unable to detect many neutrinos, but the speed measurements came from the neutrinos that were detected.

**J: Researchers spent over six months cross checking the data with no obvious errors.** This helps set the problem, but does not help answer the question.

**D: OPERA is an international collaboration of over 200 scientists from 13 countries**. This helps set the magnitude of the problem, but doesn’t answer the question.

1. Put the fact cards in the order that will most clearly explain the problem and its solution

Order:

Note to teachers: Students tend to look at a question and write in the order in which they think of ideas, not the order that present the explanation most clearly. Providing them with the facts on separate pieces of paper allows students to work together to devise a good order. It makes sense to first group the ideas dealing with setting and explaining the problem. Then deal with the ones that explain the solution. Below is one possible explanation.

Explaining the problem:

**G: The OPERA data has neutrinos arriving 60 ns earlier than expected.**

**B: The exact distance was measured precisely using advanced GPS technology.**

The combined time and distance gave the neutrinos a speed greater than that of light.

**C: Einstein’s Special Theory of Relativity does not allow objects to go faster than the speed of light.** Is relativity wrong or is the data wrong?

**F: The ICARUS experiment at Gran Sasso used the same beam and did not get the same result.**

There is probably something wrong with the OPERA data.

Explaining the solution:

**A: The master clock was ticking fast, resulting in 124 ns less time.**

**I: Inspection of the timing circuit revealed a loose connection responsible for an extra 73 ns.**

The combination of these two technical problems meant that the time was 124 ns – 73 ns = 51 ns short and accounts for most of the 60 ns error.

1. Use the information and additional connecting words and ideas to write a well-organized set of paragraphs on the back of this that answers the question. Write it in the form of a newspaper article.

Students can glue the pieces of paper onto the back of the sheet and therefore only need to write the connecting sentences. For this article, students might choose to include some of the information that isn’t absolutely necessary because it may help make the story more dramatic. Students need to keep their purpose and audience in mind when composing a piece of writing. Possible purposes include: 1) to inform; 2) to educate; 3) to persuade; 4) to control; 5) to entertain. The audience for a newspaper article is the general public. As such, usually the writing is kept simple: jargon and detailed explanations are avoided, and paragraphs are kept very brief. The famous “5W” (Who, What, When, Where, Why, How) format is loosely followed, with any details appearing near the end of the article. Another audience that the students could address is a friend who asks about this but doesn’t take physics.

1. The decision to publish results that were both controversial and unexpected led to a split within the OPERA collaboration. Several leading researchers refused to attach their names to the paper, and within months of the announcement both the OPERA spokesperson and the experiment coordinator resigned after a “no confidence” vote taken by the collaboration’s leaders. There were no allegations of wrong-doing, but some of the leaders felt that the results were brought to the public too soon. Suppose you were the OPERA spokesperson. How would you defend your decision to make the results public?

Teacher’s note: After the students have come up with some ideas, you might want to read them the quote in the following article.

<http://www.redorbit.com/news/science/1112551696/cern-confirms-neutrinos-not-faster-than-light/>

**Einstein´s Theory Of Relativity Preserved**

Physicists working at the European Center for Nuclear Research ([CERN](http://public.web.cern.ch/public/)) in Switzerland on Friday concluded once and for all that neutrinos are definitely not faster than the speed of light, preserving Einstein´s Theory of Special Relativity that was challenged by earlier experiments.

The challenge was first made last year when researchers published results of an experiment that seemed to indicate that [neutrinos](http://www.redorbit.com/topics/news/neutrino/) were moving about 3.7 miles per second faster than light. The findings from the experiment threatened to uproot Einstein´s famous 1905 theory of relativity, which states that light is the fastest matter in the universe.

The initial findings led to a whirlwind of excitement and skepticism from scientists around the globe, and physicists closer to home took it upon themselves to rework the experiments to either replicate the findings or disprove the claims.

After a second round of tests, physicists found that the neutrinos were behaving as they should and didn´t seem to show any signs of record breaking velocities.

And now, after another round of tests — conducted by Borexino, ICARUS, LVD and OPERA — researchers have confirmed that neutrinos´ cannot achieve speeds faster than light.

The news was delivered at the [25th International Conference on Neutrino Physics and Astrophysics](http://neu2012.kek.jp/) in Kyoto, Japan on Friday, in a discussion called: “The neutrino velocity measurement by OPERA experiment.”

“Although this result isn’t as exciting as some would have liked, it is what we all expected deep down,” [said](http://press.web.cern.ch/press/PressReleases/Releases2011/PR19.11E.html) the center´s research director Sergio Bertolucci. “The story captured the public imagination, and has given people the opportunity to see the scientific method in action.”

“An unexpected result was put up for scrutiny, thoroughly investigated and resolved in part thanks to collaboration between normally competing experiments. That´s how science moves forward,” he added.

The neutrinos in question were timed during their journey from CERN´s underground lab in Geneva to the [Gran Sasso Laboratory](http://www.lngs.infn.it/) in Italy, traveling some 454 miles underground in a 2011 experiment. The neutrinos should have made the trip in 0.0024 seconds, but were recorded as hitting the detectors in Italy 0.00000006 seconds sooner than expected.

After months of investigation, physicists have ruled that the speedy neutrinos observed were likely due to a faulty connection in an optical fiber of the Master Clock.

|  |
| --- |
| A: The master clock was ticking fast, resulting in 124 ns (124 x 10-9 s) less time. |
| B: The exact distance was measured precisely using advanced GPS technology. |
| C: Einstein’s Special Theory of Relativity does not allow objects to go faster than light. |
| D: OPERA is an international collaboration of over 200 scientists from 13 countries. |
| E: OPERA was designed to study how neutrinos change  form while travelling. |
| F: The ICARUS experiment at Gran Sasso used the same beam and did not get the same result. |
| G: The OPERA data has neutrinos arriving 60 ns  (60 x 10-9 s) earlier than expected. |
| H: Neutrinos do not interact very strongly with matter, making them hard to detect. |
| I: Inspection of the timing circuit revealed a loose connection responsible for an extra 73 ns. |
| J: Researchers spent over six months cross checking the data with no obvious errors. |