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Earthquakes and seismic waves worksheet

After this lesson, students should be able to: Describe waves using the correct vocabulary: amplitude, comb, trough, wavelength, frequency. Describe the relationship between the wavelength and the frequency of a wave. Explain the different types of seismic waves and how they move through the Earth. Explain the role of shakes for engineers who design structures to withstand the movements caused by seismic waves. A simple wave has a repeating pattern with a specific wavelength, frequency and amplitude. (Grades 6 - 8) More details View the aligned curriculum Do you agree with this adjustment? Thanks for your feedback! Students will gain insight into the relationships between technologies and the links between technology and other areas of study. (Grades K - 12) More details View the aligned curriculum Do you agree with this adjustment? Thanks for your feedback! For different waves, describe amplitude, frequency, wavelength and speed (Grade 8) More details View aligned curriculum Do you agree with this alignment? Thanks for your feedback! Set an alignment not mentioned above Generally know about the Richter scale magnitude, which indicates the intensity of earthquakes on a 1 to 10 (base-10 logarithmic) scale. (Pre-prepare a computer projector to show the attached PowerPoint presentation with 16 slides and short videos at the end of this introduction and make copies of the corresponding notebook.) (optional: Show students videos of the destruction caused during earthquakes of large magnitude, which can be easily found by searching on YouTube.) Why do you think engineers are worried about earthquakes? (Give students a moment to think and write down answers before asking them to share their thoughts.) Can you think of a big earthquake you've heard of in your life? (Possible examples: Japan in March 2011, Chile in February 2010, Haiti in January 2010, China in May 2008; see the list of the world's largest earthquakes..) The earthquakes in Haiti and Chile happened within a month of each other; Do you know which resulted in the most damage and led to the greatest loss of life? (Students may not know, so give them more information...) Well, the earthquake in Chile rated an 8.8 on the Richter scale, and the earthquake in Haiti was rated 7.0. This means that the earthquake in Chile was about 500 times stronger than the earthquake in Haiti. So which earthquake resulted in the most damage to man-made structures and thus the loss of life? (Listen to student guesses.) Well, reports say about 500 dead in Chile, and more than 300,000 dead in Haiti! This means that the earthquake with lower intensity caused the most damage. Why do you think this was the case? (Listen to student responses.) The reason why the lower-intensity earthquake had to cause such a large number of fatalities the lower quality of buildings and structures in Haiti compared to Chile. In the US, we have strict standards for how buildings should be built for safety reasons. During these earthquakes, some buildings remained intact, while others, including many schools and houses, completely collapsed, trapping and killing people inside. This happened because some buildings were not built to code and were unable to withstand the seismic waves produced by the earthquake. As an engineer, how would you feel if a building you designed wasn't safe and put people's lives at risk during a natural hazard, like an earthquake? An important part of engineering is improving people's lives by increasing their safety. With that in mind, if you were going to build a building in an area prone to earthquakes, would you just design a building and hope it lasted through an earthquake? How do you think you'll make sure your building survives? (Expect some students to suggest that the building should be tested.) If you want to test how well a building will survive an earthquake, how would you go about it? (Listen to student ideas.) Engineers build shake tables, which are literally tables big enough to build a building. To test their buildings properly, engineers ensure that their shakes accurately represent the earth's shaking during an earthquake. As a result, it is very important that engineers understand the various seismic waves produced during earthquakes and exactly how they cause the Earth to move. (optional; a convenient and physically active way to introduce the concept of a wave) Have you ever been to a sporting event in a stadium, like a baseball or football game, where the crowd played a wave? (See how students react. Expect most to say yes and hopefully be excited! Then let all students wave through the class, or get up and make a big circle to do the wave. Point out how you see the wave moving through the students and that they represent the medium or material the wave travels through. For more information about metachronal waves created by a large audience, see public)). (Go to showing the attached PowerPoint presentation and suggested YouTube videos along with the corresponding worksheet.) After class, see the corresponding Activity Shake It Up! Engineering for seismic waves for a fun and hands-on challenge for students to design and build their own shake tables to test and improve model buildings made of toothpicks and marshmallows before the structures undergo a simulated real earthquake challenge. the introduction students show the Engineering & Waves: Seismic Waves Presentation. The information, animations, photos and videos in the 16 slides cover golf basics, including a definition of a wave, which can be difficult for before to understand. Hand out the attached Engineering & Waves: Seismic Waves PPT Worksheet to help take notes and help students account for the information provided in the presentation. Presents students with the following information, aligned to the slides of the attached PowerPoint file. (slide 1; title slide) Ocean waves and surface waves both spread from disturbances. (slide 2; overview) This lesson deals with what waves are, how they travel, different types of waves, and how waves relate to engineering. Our focus will be on seismic waves - waves that travel through the Earth, and are usually caused by earthquakes. Wave Basics (slide 3) Wave definition: A definition of a wave is a disturbance that travels through space or time, usually through the transfer of energy. There are many different types of waves. The illustrations show sinus waves, as well as a few different types of waves that can be created by combining sinus waves. Sinus waves are one of the most well-known types of waves. Ocean waves move like sine waves. (Note to the teacher: This is a good time to mention the wave that the students acted earlier. Mention how they could see the wave moving through the class [space] for a certain amount of time. You could even point out how each other's energy and enthusiasm was transferred from one student to another to carry the wave around the class.) The terminology used to describe waves. (slide 4) Check out the basic vocabulary terms used when describing waves: wavelength, amplitude, comb, trough, frequency. See vocabulary/definition section. It is important to understand that wavelength and frequency have a relationship. When a wave has a very long wavelength, the frequency will be very low. When a wave has a very short wavelength, the frequency will be really high. Why do you think that is? (Note to the teacher: Invite students to link. Have a student draw a wave [like the one in the diagram] with a very long wavelength, while the second student draws a wave with a very short wavelength. Invite students to share their drawings and share why they think the relationship between frequency and wavelength is as you described. Choose one team to share their drawings on the board and explain their answer.) (slide 5) Types of waves: Some examples of waves are light waves, sound waves, ocean waves, seismic waves, pressure waves, compression waves and standing waves. An animation of a standing wave is provided. The nodes on the standing wave are locations where there is no movement. Standing waves can be created by sending two sine waves with the same frequency and amplitude in opposite directions to a thong. For example, you can make standing waves by holding one end of a skipping rope and letting a friend hold the other end and shaking the skipping rope up and down with the same frequency and amplitude. The locations where two waves cancel each other out are the nodes. Standing waves have important applications in musical instruments, such as guitars and violins. Engineering & Waves: Seismic waves (slide 6) Two photos show examples of the destruction caused by the seismic waves that have arisen during earthquakes. (left) This train was toppled during the 1906 earthquake in northern California. (right) During the 2004 earthquake in Chūetsu, Japan, these sewer pipes/manholes drove up and the asphalt road burst when the ground behaved like a liquid because of the stress of the sudden shaking movement (called ground liquifaction). (slide 7) A 48-second video called Earthquake Destruction shows clips taken during the 1989 Northern California earthquake and after the 1999 Taiwan earthquake. To play this as an embedded video from the PowerPoint file, you must download and save the wmv video file to the same folder as the PowerPoint file. Otherwise, click on the attached wmv file or play it directly from the YouTube website on . (slide 8) Seismic waves travel through the Earth, and are usually created by earthquakes. The two main categories of seismic waves are body waves and surface waves. Body waves travel through the earth's body and are faster than surface waves. The two types of body waves are P-waves (for primary) and S-waves (for secondary). Surface waves travel along the surface of the ground and are slower and more destructive than body waves. Love waves and Rayleigh waves are the two types of surface waves. The surface waves are similar to ocean waves where the disturbance and movement along the surface can be seen. (slide 9) P-waves (or primary waves) are the fastest of all seismic waves. P-waves move back and forth in the direction in which the wave travels. They can travel through any medium, which means air, water or earth. Some typical speeds: 330 m/s (~738 mph) through the air (a sound wave!), 1,450 m/s (~3,244 mph) by water, and 5,000m/s (~11,185 mph) by granite. (slide 10) S-waves (or secondary waves) are a different type of body wave, and as the name suggests, are the second fastest form of seismic wave, meaning that an S wave would be the second wave you would feel after an earthquake occurs. In fact, S-waves travel at 60% of the speed of P waves. S-waves are similar to the sine waves we've seen; the displacement is perpendicular (or 90 degrees) to the movement of the wave. For example, if a wave traveled to the right, the movement of the ground would be up and down. S-waves can only travel through solids. (slide 11) Love waves are one species As with S-waves, they are transverse waves, but instead of moving the earth up and down, they move the surface of the ground back and forth perpendicular to the direction the wave moves. They slower than P and S waves, but faster than Rayleigh waves. These waves were named after A.E.H. Love, the man who predicted this kind of seismic wave in 1911. (slide 12) Rayleigh waves are another type of surface wave. They cause a rolling motion along the surface of the ground, similar to the movement of ocean waves. They are the slowest of all seismic waves and travel at speeds around 3 km/s (~6.711 mph). They are created by the interaction of the P- and S-waves, and therefore indirectly are caused by the actual earthquake. Scientists and engineers have studied Rayleigh waves as a way to characterize the earth's interior and to find oil deposits, as the speed and movement of Rayleigh waves are influenced by which materials are part of the ground they travel through. (slide 13) For all seismic waves, their intensity depends on the earthquake magnitude, the distance to the earthquake, the depth of the earthquake (how far below the ground of the epicenter does the earthquake occur), and the geological structure of the earth (for example, clay, sand, granite, etc.) The amplitude of the seismic waves are smaller when an earthquake occurs far underground. The closer to the surface of the earth an earthquake occurs, the larger the amplitude. The amplitude also reduces the further the wave travels from the epicenter–this is why people in Colorado don't feel an earthquake taking place in California. The seismic waves become smaller and less destructive as they travel. (slide 14) A 2:50-minute video called Earthquake Waves is a NASA SciFi segment that explores the different types of waves that earthquakes make through the use of animations and a slinky. To play this as an embedded video from the PowerPoint file, you must download and save the wmv video file to the same folder as the PowerPoint file. Otherwise, click on the attached wmv file or play it directly from the YouTube website on . An 18-story building model placed on a new type of seismic base insulation, called earthquake protectors, is ready for shake-table testing at a university facility. (slide 15) Engineers design buildings, bridges and other infrastructure so they are safe for people, even during the extreme forces of earthquakes. To test their designs, engineers develop machines to mimic (or simulate) the ground movement of seismic waves. To do this, engineers design shake tables that accurately reproduce the movements of the Earth caused by seismic waves. All this is done to provide people living in earthquake-prone areas with stable and survivable man-built environments. This 2:51 minute video shows the largest shake table in the U.S. designed to reproduce the movement generated by the seismic waves of the 1994 Northridge earthquake in Los Angeles, CA. To play this as an embedded video from the PowerPoint file, PowerPoint file, download the video wmv file and save it to the same folder as the PowerPoint file. Otherwise, click on the attached wmv file or play it directly from the YouTube website on (slide 16) A 2:27 minute video shows the kind of amazing research being done to test earthquake-resistant construction using the world's largest earthquake shaking table, located in Japan. This video shows the simulation of a 7.5 magnitude earthquake on a seven-story building. To play this as an embedded video from the PowerPoint file, you must download and save the wmv video file to the same folder as the PowerPoint file. Otherwise, click on the attached wmv file or play it directly from the YouTube website on . Engineers build shake tables, sometimes life-size (full-size) and sometimes small, model-size, to test the ability of buildings and other structures to control the forces of seismic waves generated by earthquakes. To do this, they design and create shake tables that can accurately re-enact the earth's movements during known (and seismically recorded) earthquakes. All this is done to determine better building codes (rules) to survive structures. amplitude: Looking at a diagram of a sine wave, amplitude is the height measured from the center or rest position. Body wave: A seismic wave that travels through the Earth instead of across the surface. Comb: Looking at a diagram of a sine wave, the comb is the highest point in any wave cycle. engineer: A person who applies her/his understanding of science and mathematics to creating things for the benefit of humanity and our world. epicenter: The point on the surface of the Earth directly above where an earthquake occurs. frequency: The number of wave cycles in a given time. Frequency is often measured in hertz (Hz), indicating how many waves occur in 1 second. Love wave: A surface seismic wave that causes the horizontal shifting of the Earth during an earthquake. parallel: In the same direction. For example, on a striped shirt, the stripes are parallel. perpendicular: Meeting in a right corner (90 degrees). P-wave: A seismic pressure wave that travels through the earth's body. The fastest of all seismic waves. Rayleigh wave: A surface seismic wave generated by the interaction of P-waves and S-waves on the earth's surface that move with a rolling motion. Richter scale: The Richter magnitude scale provides a measure of the intensity of earthquakes on a 1 to 10 (base-10 logarithmic) scale. An earthquake that measures 5.0 on the Richter scale has a shaking amplitude 10 times larger and corresponds to a approximately 32 times larger than one that measures 4.0. Source: seismic wave: a wave of energy that travels through the Earth as a result of Earthquake. Shake table: a device for shaking structural models or building parts. The movement simulates the ground movements of earthquakes. Also called a shaking table. surface wave: A seismic wave that travels across the earth's surface as opposed to through it. Surface waves typically have larger amplitudes and longer wavelengths than body waves, and they travel more slowly than body waves. S-wave: A scissors or transverse body seismic wave, with movement perpendicular to the direction of wave propagation. Trough: The lowest point in each wave cycle. Wave: A disturbance that travels through space or time, usually due to the transfer of energy. wavelength: The length of each wave cycle; the distance between one comb and the next comb. Pre-Lesson Assessment Getting started: Let students work in small groups of three or four students to brainstorm waves and seismic waves. Tell them to write down all the words or thoughts that come to mind. Also let them brainstorm how they think engineering or engineers are affected by waves, or in particular, seismic waves. Let groups share their ideas with the class. Post-Introduction Assessment Skeleton Notes: While showing the attached 16-slide PowerPoint presentation, students have fill the Engineering & Waves: Seismic Waves PPT Worksheet, whichs as a skeleton for note-taking and helps students be accountable for the information presented. Teacher Summary Assessment Quiz: After completing the lesson and PowerPoint presentation, manage the Waves, Waves, Waves Quiz to rate their content knowledge. Let students research recent earthquakes to examine how well structures in those areas were able to withstand the seismic waves. For example, the severe March 2011 earthquakes in Japan hit many densely populated areas with skyscrapers. Assign them to write short reports that include descriptions of the severity of the earthquakes, data on the loss of life and structures, and each technique learned lessons (what worked, what didn't work, what can be improved). Kurczy, Stephen, Leigh Montgomery and Elizabeth Ryan. Chile Earthquake Facts: Chile vs. Haiti, in Numbers: Chile earthquake facts keep rolling in and offer blatant comparisons to the earthquake that devastated Haiti in January. Published March 2, 2010. The Christian Science Monitor. Opened October 4, 2011. largest and deadliest (World) earthquakes by year, 1990-2011. Last updated april 13, 2011. US Geological Society, US Department of the Interior. Opened October 4, 2011. world's largest earthquake Shake Test in Japan. Simpson Strong-Tie Company, Inc. Accessed April 20, 2011. (Article and a five-minute video a full-scale seven-story wooden frame tower is being tested at the world's largest shake table in July 2009, where it survived a 7.5 magnitude earthquake simulation with minor damage) The contents of this digital library curricula were developed by the Integrated Teaching and Learning Program under National Science Foundation GK-12 grant No. 0338326. However, this content does not necessarily represent the policies of the National Science Foundation, and you should not assume approval by the federal government. Last updated: 22 September 2020 2020

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