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Have you ever tossed a pebble into a still pond and watched the water dance? Those mesmerizing circles that spread out across the surface are called ripples. They're not just pretty – ripples show us how energy moves through water. Ripples form when something disturbs the water's surface, like a raindrop, wind, or a fish jumping. The disturbance pushes water up and down, creating waves that travel outward. As ripples move, they transfer energy across the water's surface. Nature puts on quite a show with water ripples. They can reveal hidden currents, warn of approaching storms, or signal underwater creatures. Next time you're near water, take a moment to watch for ripples. You might be surprised by the stories they tell about the world around us. Fundamentals of Water Waves Water waves are complex phenomena that involve energy transfer and specific physical properties. They shape our oceans and lakes in fascinating ways. Wave Characteristics Water waves have key features that define them. These include wavelength, amplitude, and frequency. Wavelength is the distance between two wave crests. Amplitude measures the height of a wave from its center to its peak. Frequency refers to how often wave crests pass a fixed point. Waves move at different speeds. This depends on factors like water depth and wave size. In deep water, larger waves travel faster than smaller ones. Wave energy also plays a role in their behavior. As waves move, they carry energy across the water's surface. Wind-generated waves can vary greatly in size. Some reach heights of nearly 20 meters in strong storms. Others barely ripple the surface in calm conditions. Interactions with Light Waves change how light behaves on water. They create patterns of bright and dark areas. This happens because waves act like lenses, focusing and spreading light. Ripples on water can make interesting shadows. These shadows often look like networks of lines on the bottom of pools or shallow areas. The shape of these patterns changes as the waves move. Light also reflects off wave surfaces. This creates the sparkly effect we often see on water. The angle of the waves affects how much light bounces off. Smooth water reflects more light directly, while choppy water scatters it in many directions. Physical Properties of Ripples Ripples on water have unique features that make them fascinating to observe. They rely on the interplay of surface tension and water density to form and move across the liquid surface. Surface Tension and Capillary Waves Capillary waves, also known as ripples, are small waves that form due to surface tension. Surface tension is the tendency of water molecules to stick together at the surface. When something disturbs the water, like a pebble or wind, it creates tiny waves. These waves are pulled back by surface tension, causing them to spread out in circles. The size of ripples depends on the water's surface tension. Stronger surface tension leads to smaller, faster-moving ripples. Water Density and Ripple Formation Water density plays a key role in how ripples form and behave. Denser water resists movement more, affecting how ripples spread. When an object enters the water, it pushes water out of the way. This creates a temporary empty space. The surrounding water then rushes back in to fill this space. As water moves back, it overshoots slightly due to its momentum. This up-and-down motion creates the ripple effect we see. Temperature can change water density, which in turn affects ripple formation. Warmer water is less dense, allowing ripples to form and spread more easily. External Factors Influencing Ripples Wind and rain play key roles in shaping water ripples. These forces from the environment add energy to water surfaces, creating unique patterns. Impact of Wind on Water Wind is a major factor in ripple formation. When it blows across water, it transfers energy to the surface. This energy creates small waves that move in the wind's direction. Strong winds make bigger ripples. Light breezes cause gentle, small ripples. The ripple size depends on wind speed and how long it blows over the water. Wind direction matters too. It affects how ripples spread out. Ripples may move in straight lines or curve, based on wind patterns. Rain and Ripple Patterns Rain creates fascinating ripple patterns on water. Each raindrop acts like a tiny stone thrown into a pond. It makes circular ripples that spread out from where it lands. When many raindrops fall at once, their ripples mix together. This creates complex, overlapping patterns on the water's surface. The size of raindrops affects ripple patterns too. Big drops make larger ripples, while small drops create tinier ones. Heavy rain can cause more chaotic ripple patterns. Light rain often results in more uniform, gentle ripples. The height from which rain falls also influences the energy it adds to the water, changing ripple shapes. Ripples Across Various Water Bodies Ripples take on different forms depending on the body of water. The size, shape, and behavior of ripples vary between lakes, oceans, and rivers due to differences in wind patterns, depth, and water movement. Ripples in Lakes Lakes often have smaller, gentler ripples compared to oceans. Wind creates tiny waves called capillary waves on the lake surface. These ripples are governed by surface tension. As wind speed increases, larger ripples form. In shallow areas near the shore, ripples may break and create small waves. Deep lakes can have bigger ripples in windy conditions. Lake ripples tend to be more uniform than ocean ripples. This is because lakes have less water movement and smaller fetch (the distance wind blows over water). Oceanic Ripples Ocean ripples are typically larger and more varied than lake ripples. Strong winds can create big ripples that travel long distances across the ocean surface. Wind-generated swells in oceans form ripples that move far from their source. These ripples can combine to make larger waves. Ocean depth affects ripple size. In deep water, ripples grow bigger as wind pushes them. Near the shore, ripples become shorter and steeper as they enter shallow water. Tides and currents also shape ocean ripples. They can make ripple patterns more complex and constantly changing compared to calmer lake surfaces. Mathematical Modelling of Ripple Dynamics Waves and ripples in water can be described using mathematical equations. These models help us understand how ripples form and move. Let's look at the math behind ripples and how we can measure them. The Equation of Waves The wave equation is key to understanding ripple dynamics. It's a mathematical formula that describes how waves move through water. Here's a simple version: $\partial^2 y/\partial t^2 = c^2(\partial^2 y/\partial x^2)$ In this equation: y is the wave height t is time x is distance c is wave speed This equation shows how the wave's shape changes over time and space. It helps predict how ripples will spread out on a water surface. Scientists use more complex versions of this equation to model real-world ripples. These models take into account things like water depth and surface tension. Measuring Wave Parameters To study ripples, researchers need to measure different wave features. Here are some key parameters they look at: Wavelength: The distance between wave peaks Amplitude: The height of the wave from its middle to its peak Frequency: How many waves pass a point in a given time Speed: How fast the wave moves across the water Ripple tank experiments help scientists measure these features. They use special tools to track ripple movement and size. Computer programs can also model ripples. These programs use the wave equation to create virtual ripples. This lets scientists study ripples in different conditions without needing a real water tank. Understanding Wave Patterns and Behaviors Water ripples create fascinating patterns as they move across surfaces. These patterns range from tiny ripples to large waves, each with unique behaviors and shapes. From Ripples to Megaripples Ripples form when something disturbs the water's surface. They start small and can grow bigger. Wind or objects hitting the water cause these patterns. Ripples are tiny waves, just centimeters high. As they grow, they become megaripples. These are over 5 cm tall and several meters wide. The size of ripples depends on: Wind speed Water depth How long the wind blows Bigger disturbances make larger ripples. In shallow water, ripples grow faster than in deep water. Circle Formation and Spread When an object hits water, it makes circular ripples. These circles spread out from where the object landed. The pattern looks like rings getting bigger and bigger. Each ring is a wave moving away from the center. The waves slow down as they spread. This is why the circles get farther apart as they move. Ripples can also bounce off objects. When they do, they create new patterns. Sometimes, ripples from different sources meet and make criss-cross shapes. The circles keep spreading until they run out of energy. Wind or other waves can change their shape as they move. Impact of Waves on Nature and Environment Waves shape our planet's coasts and underwater landscapes. They create beautiful shorelines and unique rock formations. But waves can also cause problems like erosion and flooding. Erosion and Wave Energy Waves carry a lot of energy. When they hit the shore, they can wear away rocks and soil. This process is called erosion. Over time, waves can change the shape of coastlines. Big waves during storms can cause major damage. They can wash away beaches and destroy cliffs. In some places, whole islands have disappeared because of wave erosion! Waves also move sand and pebbles around. They can create new beaches in some spots while taking sand away from others. This constant movement helps keep coastal ecosystems healthy. Geological Formations From Waves Waves don't just destroy – they also build amazing rock formations. Sea stacks, arches, and caves are all made by waves hitting cliffs over many years. Wave action carves out interesting shapes in rocks. It can make smooth, round pebbles from jagged stones. Waves also help form sand ripples on beaches. In some places, waves build up layers of sand and rock. This can create new land features like spits and barrier islands. These formations help protect the coast from storms and provide homes for many plants and animals. Waves play a big role in shaping our world's shorelines. They're a powerful force of nature that's always changing the environment around us. Human Interaction with Water Waves People interact with water waves in many fun and interesting ways. These interactions can be both playful and educational, leading to new discoveries about how water moves and behaves. Recreation and Education Kids and adults alike enjoy playing with water ripples. Skipping stones across a lake creates circular ripples that spread out in mesmerizing patterns. Splashing in puddles or pools sends waves bouncing off the edges, creating complex interference patterns. Many science museums have wave tanks where visitors can make ripples and observe their effects. These hands-on exhibits help people understand wave behavior through play. Some beaches offer guided "tidepool walks" where naturalists explain how waves shape coastal ecosystems. Water parks use wave machines to create artificial surf for bodyboarding and swimming. These controlled waves give people a safe way to experience ocean-like conditions far from the coast. Scientific Observations and Studies Scientists study water waves to learn about fluid dynamics and energy transfer. They use special tanks with precise wave generators to test theories about how waves form and move. Researchers observe natural waves too. They set up cameras and sensors near shorelines to track wave patterns over time. This data helps predict coastal erosion and flooding risks. Some scientists even study how raindrops create ripples when they hit puddles or ponds. These tiny waves can teach us about larger ocean waves and weather patterns. Student projects often focus on water waves. Simple experiments like dropping objects in water and measuring ripple speed help kids learn basic physics concepts. Large-Scale Water Movements The ocean has powerful forces that can create massive waves. These waves can move huge amounts of water across long distances. They can affect coastal areas and even reach far inland. Understanding Tsunamis Tsunamis are giant waves caused by underwater events like earthquakes or landslides. They can travel very fast across the ocean, up to 500 miles per hour. When tsunamis reach shallow water near land, they slow down and grow taller. Ocean currents help tsunamis move across the ocean. As the wave approaches shore, it can reach heights over 100 feet tall. Tsunamis can cause major flooding and damage to coastal towns. Scientists use special systems to detect tsunamis. This helps warn people to move to higher ground. Stronger buildings and sea walls can also protect against tsunami damage. Tidal Wave Phenomena Tidal waves are different from tsunamis. They are caused by the gravitational force of the moon and sun. These forces pull on the ocean, creating high and low tides. Tidal waves can be very big in some places. The Bay of Fundy in Canada has tides that rise and fall up to 50 feet. This happens because of the bay's shape and size. Some rivers have tidal bores. This is when the incoming tide pushes a wave upstream. The Amazon River has a tidal bore that can be 13 feet high. Surfers sometimes ride these waves for fun. Factors Affecting Ripple Velocity and Movement Water ripples move in complex ways. Their speed and motion depend on several key factors. Let's explore the main influences on ripple velocity and movement. Currents and Wave Speed Currents play a big role in how ripples move. Faster currents make ripples travel quicker. Water depth also matters. In deeper water, ripples can move faster. Wave speed affects ripple movement too. Bigger waves with more energy create faster-moving ripples. Wind strength impacts this. Strong winds whip up bigger waves, leading to speedier ripples. Ripple crests move at different rates. Some zip along quickly, while others lag behind. This creates a dynamic pattern on the water's surface. Dispersion and Group Velocity Dispersion describes how waves of different wavelengths travel at various speeds. This affects ripple movement. Longer waves typically move faster than shorter ones. Group velocity is the speed at which a group of waves travels. It's often different from individual wave speeds. This creates interesting ripple patterns. In shallow water, dispersion is less noticeable. Ripples tend to move together. But in deeper water, dispersion becomes more apparent. Ripple groups can spread out or bunch up. Wind can change group velocity too. It pushes some ripples faster than others. This leads to evolving ripple shapes and patterns on the water surface. Ripple-related Natural Phenomena Water ripples are linked to many fascinating events in nature. These patterns appear in various settings and can teach us about the world around us. Watching Splashes and Their Effects When a rock hits water, it creates a splash. This splash pushes water out of the way, making ripples. The ripples move away from where the rock landed in a circle shape. Splash rocks are fun to watch. They make different patterns based on their size and how they hit the water. Big rocks make big splashes with lots of ripples. Small pebbles make tiny splashes with small ripples. Kids often like to skip stones on water. This creates a series of small splashes and ripples. Each time the stone touches the water, it makes a new set of circles. Transverse Aeolian Ridges in Nature Transverse Aeolian Ridges (TARs) are like ripples, but they form on land instead of water. Wind creates these patterns in sandy areas. They look like small waves frozen in place. TARs are found in deserts and on other planets like Mars. Scientists study these ridges to learn about wind patterns and how sand moves. On Earth, TARs can be a few inches to several feet tall. Wind speed affects how TARs form. Stronger winds make bigger ridges. The size of sand grains also changes how TARs look. Fine sand makes smoother ripples, while coarser sand creates rougher patterns. Water is also made of molecules. But during a ripple, the water molecules don't move away from the rock, as you might expect. They actually move up and down. When they move up, they drag the other molecules next to them up – then they move down, dragging the molecules next to them down too. What are the ripples in water called? Capillary waves are common in nature, and are often referred to as ripples. The wavelength of capillary waves on water is typically less than a few centimeters, with a phase speed in excess of 0.2–0.3 meter/second. Ripples are the instant effect of wind on water and they die down as quickly as they form, as the surface tension of the water dampens their efforts. If a wind blows steadily across a large enough patch of water for a few hours then the ripples become waves and these will not be dampened so easily. See also How do you calculate average power?What are ripples in physics? A ripple is defined as the fluctuating AC component in the rectified DC output. The rectified DC output could be either DC current or DC voltage. When the fluctuating AC component is present in DC current it is known as the current ripple while the fluctuating AC component in DC voltage is known as the voltage ripple. What causes the ripple effect? A ripple effect occurs when an initial disturbance to a system propagates outward to disturb an increasingly larger portion of the system, like ripples expanding across the water when an object is dropped into it. Ripples are little waves on the surface of water caused by the wind or by something moving in or on the water. Is a ripple a wave? A ripple is a small wave on the surface of something, such as a ripple that forms a ring around the spot where you threw a pebble into the pond. Ripple can also be a verb. For example, you might see raindrops ripple on top of a puddle. What do ripples represent? The ripples that appear in a flat surface of water when you throw a pebble into it are often used as a metaphor for the effects of our actions in life—the ones that extend out beyond where we can observe them. Gravitational waves are 'ripples' in space-time caused by some of the most violent and energetic processes in the Universe. Albert Einstein predicted the existence of gravitational waves in 1916 in his general theory of relativity. See also What is the symbol for mass density?Do water ripples behave like sound waves? When water waves traveling long distances across the ocean flow around a headland or into a bay, they spread out in circles like ripples. Sound waves do exactly the same thing, which is why we can hear around corners. Is a water ripple A transverse wave? In a transverse wave, the particles are displaced perpendicular to the direction the wave travels. Examples of transverse waves include vibrations on a string and ripples on the surface of water. When a wind or water current flows across loose sand, the sand is dragged along the bottom and frequently is piled up to form ripples and dunes. The main difference between a ripple and dune is size, with dunes being taller than about 10 cm. What is a ripple effect example? The act of tossing a small stone into the water will result in a change that can be felt much farther away than the initial entry point—proof that small actions can lead to much bigger changes, even if you can't see how far they can reach. Is the ripple effect positive or negative? The ripple effect is a situation in life in which when one thing occurs, it has a direct effect on other situations and the chain goes on and on and on. Most often, the effect is spoken about positively. Voltage ripple Ripple itself is a composite (non-sinusoidal) waveform consisting of harmonics of some fundamental frequency which is usually the original AC line frequency, but in the case of switched-mode power supplies, the fundamental frequency can be tens of kilohertz to megahertz. What is another word for ripple effect? causal sequence. contagion effect. dispersion. dissemination. domino effect. knock-on effect. overspreading. slippery slope. Who developed the ripple effect theory? Gravitational waves produced by two orbiting black holes. Scientists have announced the first direct detection of gravitational waves on Earth by the Laser Interferometer Gravitational-Wave Observatory (LIGO). These elusive ripples in the fabric of space-time were first predicted by Albert Einstein a century ago. How do you demonstrate the ripple effect? 1 : to move or cause to move in small waves The lion's muscles rippled. A breeze rippled the water. 2 : to pass or spread over or through Laughter rippled through the crowd. ripple. noun. What do you conclude moves vertically and what moves horizontally in the water ripple? These ripples produced, or the water waves that are formed at the surface of the water in a pond, are also called "transverse waves." This is because, in a water wave, the water molecules move up and down in a vertical direction when the water travels in a horizontal direction along with the water surface. Where do ripples occur? The current ripples are characterized by the orientation of longitudinal axis of ripples transversely to the direction of flow and properly arranged crests and troughs. Little current ripple marks occur in muddy and fine grain sand and limestone sediments in river environments, on the tidal plains and sandy beaches. Ripples are relatively small, elongated ridges that form on bed surfaces perpendicular to current flow. With continuous current flow in one direction, asymmetrical ripples form. Asymmetrical ripples contain a steeper slope downstream. See also What is the longest equation ever?How are current ripples formed? When water flowing over sand exceeds the critical shear stress for motion, bedforms develop as a result of dynamic processes acting across the interface between sand and water. For grain sizes finer than coarse sand, the first flow-transverse bedforms to develop are current ripples. What is ripple structure? Ripples, ripple marks, or ripple structures can be defined as small-scale, flow-transverse ridges of silt or sand produced by fluid shear at the boundary between moving water or air and an erodible sediment bed. When someone we love dies, it affects our whole pond. We call those ripples that go beyond the loss of the loved one secondary losses. Secondary losses can feel especially painful during the holiday season, as survivors face an empty chair at the table or changes in a cherished annual ritual. Page 2Water is also made of molecules. But during a ripple, the water molecules don't move away from the rock, as you might expect. They actually move up and down. When they move up, they drag the other molecules next to them up – then they move down, dragging the molecules next to them down too. What are the ripples in water called? Capillary waves are common in nature, and are often referred to as ripples. The wavelength of capillary waves on water is typically less than a few centimeters, with a phase speed in excess of 0.2–0.3 meter/second. Ripples are the instant effect of wind on water and they die down as quickly as they form, as the surface tension of the water dampens their efforts. 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These elusive ripples in the fabric of space-time were first predicted by Albert Einstein a century ago. How do you demonstrate the ripple effect? 1 : to move or cause to move in small waves The lion's muscles rippled. A breeze rippled the water. 2 : to pass or spread over or through Laughter rippled through the crowd. ripple. noun. What do you conclude moves vertically and what moves horizontally in the water ripple? These ripples produced, or the water waves that are formed at the surface of the water in a pond, are also called "transverse waves." This is because, in a water wave, the water molecules move up and down in a vertical direction when the water travels in a horizontal direction along with the water surface. Where do ripples occur? The current ripples are characterized by the orientation of longitudinal axis of ripples transversely to the direction of flow and properly arranged crests and troughs. 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When someone we love dies, it affects our whole pond. We call those ripples that go beyond the loss of the loved one secondary losses. Secondary losses can feel especially painful during the holiday season, as survivors face an empty chair at the table or changes in a cherished annual ritual. The ripple effect. Forance/Shutterstock. Writing in The Conversation, Professor Simon Cox from the Department of Mathematics explains why the simple experiment of throwing a rock into water actually reveals some fundamental rules of physics:When I was playing "splash rocks", I noticed that when I threw the rock into the river it made a circle shape, which got bigger. How does it make the ripple? Why do the circles spread out further and further? Why do they stop? – Rowan, aged six, UK.Hi Rowan, these are good questions, and a fun experiment to do.When you throw a rock into a river, it pushes water out of the way, making a ripple that moves away from where it landed. As the rock falls deeper into the river, the water near the surface rushes back to fill in the space it left behind.The water usually rushes back too enthusiastically, causing a splash – and the bigger the rock, the bigger the splash. The splash then creates even more ripples that tend to move away from where the rock went into the water.When water is in its calmest, lowest energy state, it has a flat surface. By throwing the rock into the river, you have given the water some energy. That causes the water to move around, trying to spread out the energy so it can go back to having a still, flat surface.This follows a powerful principle of physics, which is that everything seeks to find a state where its energy is as small as possible.One way energy can move around is by forming waves. For example, the waves you see at the beach are formed by energy from the wind. Light and sound also move in waves, though we can't see that directly. And the ripples that you see in the river are small waves carrying away the energy from where you threw the rock.Up and downYou might already know that everything you can touch is made up of lots of tiny molecules, which are themselves made up of even smaller parts called atoms.Water is also made of molecules. But during a ripple, the water molecules don't move away from the rock, as you might expect. They actually move up and down. When they move up, they drag the other molecules next to them up – then they move down, dragging the molecules next to them down too.That's what creates the peaks and troughs you see on the surface of the water. And that's how the ripple travels away from your rock – a bit like a human wave around a stadium.Dragging neighbouring water molecules up and down is hard work, and slowly uses up energy, so the ripples get smaller as they get further away. Eventually, the ripples use up all the energy from the rock and the splash, and shrink until we can no longer see them.Rippling outRipples often spread out in circles, but this isn't the only possibility. If you throw a stick into the water it will create straight ripples on the sides, and round ripples near the ends. So your rock probably made circular ripples because the rock itself was quite round.But something else is happening too: different waves move at different speeds. Waves with a lot of energy move more quickly. For example, really big tidal waves, or tsunamis, race across the ocean as fast as a plane flies (up to 800 kilometres per hour).When you throw a stick into the water, the ripples from the middle of the stick eventually catch up with the ripples from the ends, because of the different ways they spread out. So far away from the stick, the ripples are round … just like they were for your rock.Simon Cox, Professor of Mathematics, Aberystwyth UniversityThis article is republished from The Conversation under a Creative Commons license. Read the original article.Curious Kids is a series by The Conversation, which gives children the chance to have their questions about the world answered by experts. If you have a question you'd like an expert to answer, send it to curiouskids@theconversation.com. We won't be able to answer every question, but we'll do our very best. Water, waves, and ripples You are sitting on a dock on the bank of a small lake just before sunset. It's the time when there is no wind, and the lake is calm, very calm. The light hits the water at a flat angle, so you can see the slightest disturbance of the surface. The water is flat. Then you feel the slightest breeze on you cheek, and it continues for some time. Never the less, the water is flat. After a while the wind freshens, and finally you see ripples on the water. As the breeze turns into a blow, the waves become higher and the distance between the waves becomes longer. What's going on here? Is it interesting? I think it's interesting, or I wouldn't be writing this (also see). First, look closely at the surface of the water before the wind comes up. It appears flat, but a very close inspection reveals a complex collection of very small waves moving at different speeds in different directions. How small the waves are depends on the environment, but there are always some disturbing forces, animals, sound, leaves falling in the water, anything. There will be a few waves moving in the direction of the wind. The wind will transfer the most energy to these waves, and they will grow in size and finally move almost as fast as the wind. Gradually these waves will dominate the surface profile of the water, as seen in the diagram to the right. You can think of this process as evolution and selection. Wait, what do we hope to learn? I hope your interest in waves has been wetted, but we need to be a little realistic about what we plan to discuss in this tiny essay. There are so many things about waves that are interesting. For example, there are hundreds of papers just on the process described above, the interaction of wind with water. There are also many layers to understanding waves, but most of them require familiarity with advanced mathematical concepts. Here our goal must thus be modest: the relationship between wavelength and speed for wind driven water waves. This may seem a little too modest a goal. However, I will try to convince you that, while not the Holy Grail, it is still worth some effort. As in many quests, we will learn some unexpected things in our search. Four types of forces add to make waves 1. Disturbing forces: We described above the one we are interested in, the force due to wind interacting with the water surface. This can be complicated, but all we say about it here is that for the wind to put energy into the waves they must be moving slightly slower than the wind. If the waves are moving faster they will instead loose energy to the air. 2. Restoring forces: There must be at least one force that pushes or pulls the water surface back to its original flat position, otherwise we won't have waves, the water will just fly out of the lake. The first restoring force is obvious: Some portions of the blue water on the left are above, and some are below the resting level of the water. Gravity forces the higher water down and the lower up, as indicated by the green arrows. How gravity can force water up will be discussed later. Wait: If that is all that was going on, the surface of the water will just go up and down to generate waves like the other two red curves in the above diagram. These waves don't move, they just go up and down. Such waves do exist and they are called "standing waves" . Great, but we want waves that move to the right with the wind. How gravity can force water up from the trough of the wave to the resting level will be described later. Gravity: F = g d F: force per unit volume g: gravitational force per unit mass d: the density of the water or mass per unit volume Surface tension: F = T curvature F: force per unit length at surface T: surface tension of the water curvature: the second derivative of the surface; how rapidly the surface bends Water molecules are attracted and bonded to each other by hydrogen bonds. However, at an air-water surface each water molecule can only bond to water below it. The overall effect is a force to minimize the total surface area. Mathematically this is equivalent to a force proportional to the second derivative of the surface. It is as if the water surface was a thin sheet of stretched rubber. If the left and right edges of the surface in this diagram were fixed, surface tension (the red arrows) would tend to flatten the surface (the green arrow). 3. Inertial and mass conservation forces: It may seem strange to group these two internal forces together, but it won't change the physics, so here goes. By inertial forces I refer to Newton's basic law that says objects move at a constant velocity unless a force is applied. The force required per change in velocity (acceleration) is proportional to the mass. F = m a A change in velocity can mean a change in speed or a change in direction. A simple example of a change in direction is an object moving in a circle, as on the left diagram. The velocity is constantly changing toward the center so a force toward the center is required. Of course this is just the situation when the earth revolves around the sun; the force is the force of gravity between the earth and sun. It also turns out to be the situation when a water wave moves to the left (see below). By conservation forces I mean pressures that maintain balanced flows. Balanced flows ensure the amount of water flowing into a region equals the amount flowing out; water is neither created or destroyed. This principle is also called conservation of mass. Imagine that the water is divided into many imaginary squares (we assume there is no flow in the plane of the diagram) so we can do the book keeping. On the left there are horizontal (H) and vertical (V) flows. In the horizontal direction the flow in on the right, H1, is less than the flow out on the left, H2. The resulting loss of water must be balanced by an increase from vertical flows V1 and V2. H1 - H2 = V1 - V2 It is this system of pressures that allow the downward force of gravity on the crest of waves to also force the water in the troughs upward, as seen in a previous diagram. The water in the crests is connected to the water in the troughs. 4. Dissipative forces: As internal currents in water flow past each other, and as the water flows over the bottom and sides of the lake (or river, ocean, bay, or whatever) energy is lost due to molecular friction. The loss of energy is proportional to the viscosity of the water. If the wind should stop suddenly, the waves will gradually decrease in size and the lake will become calm again. This is reassuring, but we will not pursue this process any further here. In the diagram on the right we have a wave moving to the right (blue wave moving to the red wave). An obvious way for this to occur would be for all the water to just move to the right, transforming the blue to the red curve. But, as anyone who has been in a boat knows, this isn't what happens when a train of waves passes under you. The entire water isn't moving with the wave, instead it just feels like you are going up and down with the waves. Actually, in the boat you are going up and down and left to right. This is because the water at each point moves in a circle; the small red arrows show the velocity of the water at each part of the wave cycle. One take home lesson here is that calculation of the velocities is a little complex, and requires some maths. Using these forces the velocities of water in a wave traveling at constant speed to the right can be found. Below I give you a bonus (because I said all we would learn is the relationship between the velocity of the wave and its length), the movement of water at various parts of the wave. Now, what I promised, speed versus wave length (as an approximation good for deep water): v2 = [g L / 2 pi] + [2 pi T / d L] where pi = 3.14159..., g = gravity constant, L length, T surface tension, d density I consider the velocity the independent variable, plotted on the horizontal axis, because it is defined by the wind. The wave length is the response of the water to the wind. I have used a log-log plot only because I want to show a wide range of velocity values. To give the metric impaired a feeling of scale, 1 m is about one yard and 1 m/s is 3600 m/hr or 3.6 km/hr or 2.2 mph. The straight black line is the response if the surface tension were zero, while the red line is the response for clean water. Look closely at the equation and its curve and behold! First, for clean water there is a minimum velocity for water waves; the bend in the red curve. Thus, as suggested in the very first paragraph of this essay, winds with velocities less than 0.23 m/s can't make waves. You can also see this from the equation, since for small L the second term becomes large while for large L the first term is large; there is no L where v becomes zero. Since the first term is due to gravity, and the second depends on surface tension, another way to state this is: long waves move fast using gravity while short waves move fast using surface tension. This is a specific example of a very important principle: the forces that are important depend on the size scale of interest. Secondly, for any wind that can make waves, there will be two wavelengths. However, at velocities above 1m/s the wave lengths of the small waves become quite small (less than 1 mm). The ripples rely on surface tension of the water, while the large wave uses gravity as the restoring force. I have used the phrase "clean water" several times when mentioning surface tension waves. That is because the value for the surface tension of water is very dependent on the surface being water, not oil or protein or soap or anything else. It takes a very small amount of any material which floats, oil for example, to produce a film one molecule thick on the surface. The surface of the ocean is never (well hardly ever) water, there are to many living and dead organisms in the ocean, thus too high a concentration of oils, proteins, etc. Written by John StaughtonLast Updated On: 19 Oct 2023Published On: 7 Feb 2020 Table of Contents (click to expand)What Is A Ripple?Ripples Vs Waves Vs SwellsA Final Word Ripples in water are more formally known as capillary waves, and are caused by the subtle interaction of wind and water, or the physical interaction of the water with another object. Have you ever stood at the edge of a lake on a hot summer day and stared out across the water? Even if there isn't a whisper of wind against your face, you will likely still see faint lines and irregularities in the water. The light will reflect off movement at the surface, and small ripples will be seen in patches, sometimes appearing to move in different directions. Imagine picking up a stone and chucking it into the lake, where it lands with a satisfying splash, and an expanding ring of ripples will appear. How are these created? (Photo Credit : YJ.K/Shutterstock) These patterns and shapes that we see or create in water bodies are commonly referred to as ripples, but why do they form and what affects how long they last? Recommended Video for you:Why Don't Lakes Just Evaporate or Seep Into the Ground? Even on a day when you don't feel any wind, there will always be some movement in the air, and at the surface of a water body, that movement causes small ripples to form. Wind energy is being transferred to the minuscule water molecules, which begin to move up and down, gently rising and falling, pulling along with the molecules beside them. However, the surface tension of water is quite strong, due to the polar nature of water molecules, and this tension will stop the ripples from perpetuating very far or for very long. The energy transferred into the water is quickly used up in moving those molecules up and down, so the ripples fade. This is what gives the ripples on a lake their transient, sparkling appearance, as they briefly rise and catch the light before settling back into stillness. When you throw a rock into a body of water, the rock will push water out of its way as it enters, causing ripples to move away from its point of entry in a circle or ring shape. Water will then rush back in to fill the empty space, which can often cause a splash, resulting in more ripples forming. You can try this yourself by dropping a marble straight down into a bowl of water. Watch the resultant splash rise straight up and then fall back in, sending out a second ring of ripples. The larger the rock, the greater the effect and the stronger the ripple, meaning that it will last longer before disappearing. The reason that these ripples don't behave like waves on a beach is because they aren't strong enough; they lack the energy to persist in the face of water's strong surface tension. These types of ripples may also form when water is moving in a certain direction and encounters an obstacle, such as a fishing boat, a breakwall, or even your feet as they dangle off a dock! Water molecules will encounter an object and move upwards against it, before being pulled back down by the neighboring molecules. This interaction causes a ripple to form that moves in the opposite direction of the water's initial motion. Now, while a ripple is a type of wave motion—a capillary wave, to be precise—when we are talking about water bodies, there is a clear difference between a ripple and a wave. As mentioned above, a ripple is a transient, short-lived phenomena that quickly disappears once its input energy is used up. However, if wind continually moves over a body of water, creating a steady stream of ripples, they can begin to accrue more energy, and will turn into waves, like those you might see crashing on a beach. While ripples are unable to overcome the force of surface tension, waves can build up enough energy to do so if the wind blows steadily over a large enough patch of water. Such waves will always flow in the same direction as the wind, and will shift direction if the wind changes. When waves move into shallower water, the bottom part of the wave will decrease in speed, and the top part of the wave will overtake it, causing the wave to break. This can also be seen in the ocean open, particularly during a storm or when the seas are choppy, i.e., when different weather systems are interacting, or when the wind is rapidly changing direction. If the wind is persistent and strong, it can begin to generate the most persistent type of movement—a swell. While waves always move in the same direction as the wind, a swell forms when those waves move out of the area they were initially made. The water of a swell has gathered enough energy and momentum that it can actually move against the wind, sometimes traveling vast distances, across entire oceans, without losing its energy. A swell is typically difficult to see against the horizon, as it is often longer, more even and slower-moving than normal waves. Also, the distance between the troughs and peaks of a swell is usually much greater than that distance in waves formed by the wind. Clearly, water is able to store and harness a lot of wind energy under the right conditions, but ripples are simply too transient, too small and have too little energy to persist and travel for long distances. However, if you get a large enough rock and drop it from a high enough height, you may be able to create a ripple that travels out from the middle of the lake to the shoreline! References (click to expand) John Staughton is a traveling writer, editor, publisher and photographer who earned his English and Integrative Biology degrees from the University of Illinois. He is the co-founder of a literary journal, Sheriff Nottingham, and the Content Director for Stain'd Arts, an arts nonprofit based in Denver. On a perpetual journey towards the idea of home, he uses words to educate, inspire, uplift and evolve. Related Videos