Exploring wave motion
Properties of waves

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A stormy sea is one of the most awesome demonstrations of the power of nature. Waves crash against the coast with enough energy to turn over cars and destroy buildings but how is that energy transferred from the deep water where the waves are generated? Rather less violent, but equally inspiring, is the rainbow which is sometimes left behind when the storm has passed. Both of these natural phenomena are examples of wave motion, and that's what this video is all about. To understand wave motion, I'm going to have to develop a mathematical description of an idealised wave, which can then be applied to all sorts of 'real world' situations. So what exactly is a wave? Well, a wave is really a mechanism by which energy gets transferred from one place to another. And that idea can be seen here in the wave pool at a holiday resort. A moving paddle behind the wall generates waves which travel away from the wall, and are eventually dissipated on the sloping beach. Well, here's a scaled-down and simplified version of the wave pool. It's called a ripple tank, and I'm going to use it to illustrate the key features of waves. Waves are generated at this end. And if I turn it on you can see that the cylindrical paddle oscillates, and that drives the surface of the water up and down and creates a series of parallel waves that travel along the tank in this direction. These sloping beaches round the edge are just to stop reflections and allow us to concentrate on the parallel wave crests that move along. But to actually look at a single wave crest as it moves along is rather difficult, so to do that we've got a diagram that shows it. The wavy line represents the surface of the water as we look from the side, and the height of the waves has been exaggerated. This is the profile of the wave and it's moving to the right at a constant speed. If we freeze the motion, you can see three wave crests with troughs between them. The amplitude of the wave is defined as the maximum displacement of the water surface from its mean position. It's equal to half the peak-to-trough displacement of the wave and it's usually denoted by a capital 'A'. We can also use this static picture of the wave to define its wavelength. This is equal to the horizontal distance between two corresponding points on the profile – these might be two adjacent crests, but two troughs would do just as well, or any other pair of corresponding points. The wavelength of a wave is represented by the Greek letter '*lambda*'. In fact you can think of this snapshot of the wave as a graph showing the vertical displacement of the wave, as a function of distance, at a particular instant of time. Let's start the wave moving again. In the ripple tank it's rather difficult to see the waves from the side like this. So to improve things we've put a strong directional source of light up there, which shines through the surface of the water, projects onto this mirror down here, and throws an image forward onto the screen. And here you can see the parallel wave crests moving down the screen. If we freeze the picture here for a moment you can see that the wavelength is the distance between two adjacent wave crests. Let's start things moving again and think about the idea of the speed of the wave. How would you measure the speed if you were sitting beside the tank watching the wave pass a particular point? Well, here's the graphical representation we had before, showing a side view of the wave. For the moment I want you to concentrate on the behaviour of the water surface at one particular point. As the wave passes by the water surface at this point is simply moving up and down periodically. Let's forget about the distance axis and consider the periodic up and down motion of this point on its own. In order to see how the displacement of this spot varies with time we can plot a graph of displacement against time. This curve looks very much like the static wave profile you saw earlier, but it's actually a plot of the motion of one particular position on the water's surface, against time. It still shows the amplitude of the wave which has the same definition as before. But now the separation between two crests of the wave profile is an interval of time. This time interval is known as the period of the waves and it's usually represented by a capital 'T'. This is the time it takes the spot to do one complete cycle. So what's the relationship between the period of a wave and its wavelength? Well, here's the displacement versus distance graph again. Let's watch exactly one cycle and then freeze the action. During a time interval equal to one period the wave has travelled forward a distance equal to

one wavelength. So the speed of the wave, which is defined as the distance travelled divided by the time taken, is simply the wavelength divided by the period.