Exploring wave motion
Oscillation and wave speed

Commentary
Okay, so what do you think would happen if the paddle were moving up and down at a different rate? Would it change the speed of the waves? Well, I can alter the rate of the paddle using this control here. So first of all, if I slow it down you can now see that the wave crests are further apart. The wavelength is longer. But they're still travelling at the same speed along the tank. Alternatively, if I increase the rate at which the paddle moves up and down, now the wavelength's much shorter, but again, the waves are travelling at the same speed down the tank. So the speed of the waves is independent for any particular tank of water. Let's take a look at this, using our graphical representation. This is the original displacement against distance graph of the water surface. With a digital clock you can see that the wave takes two seconds to travel a distance of one wavelength. So the period of this wave is two seconds. This means that only half a cycle of the wave passes by a fixed point in one second. If the rate of the paddle, and hence the rate at which the water moves up and down is now reduced by a factor of two, say, the wavelength becomes longer as we saw in the tank. Since the speed of the wave is unaffected it now takes four seconds to travel a distance of one wavelength, that's only one quarter of a complete cycle, passing by each second. On the other hand, if the paddle moves up and down more rapidly, the wavelength becomes shorter. In this case, the wave takes only one second to travel a distance of one wavelength. So, with the paddle oscillating like this, one complete cycle goes past every second. The number of cycles passing any point per second is known as the frequency, and it's equal to the reciprocal of the period – 'f equals one over T'. If the period is two seconds, the frequency must be half a cycle per second, and so on. So, you now have two relationships that are true for all waves – speed equals wavelength over period, and frequency equals one over period. Expressing the right hand side of the first equation as 'one over T times lambda' and substituting 'f' for 'one over T' gives the fundamental equation of wave propagation. Speed equals frequency times wavelength. Frequency – the number of complete cycles that pass a fixed point per second – is measured in hertz. And at the moment, the paddle is oscillating about six times a second, so that's a frequency of '6 hertz'. Now, if I double that frequency to about 12 Hz, that means that the frequency of the water waves is about 12 Hz, but the wavelength has halved, so the speed remains the same. And if I were to decrease the frequency again by a factor of two, then the wavelength would double, and once again the speed would stay the same. This illustrates the important result that the frequency of a wave multiplied by its wavelength gives a constant number – the speed of the wave. So a long wavelength corresponds to a low frequency, while a short wavelength corresponds to a high frequency. Although the speed stays the same at different driving frequencies, it does depend on things like the geometry of the tank and the nature of the fluid through which the wave travels.