SCIENCE MUSEUM

WONDERLAB: THE EQUINOR GALLERY

The science and maths behind the exhibits

INFORMATION	Age	Topic	
i	7–11 11–14	SOUND	30 MIN
	Location	LEVEL 3, SCIENCE MUSEUM, LONDON	

What's the science?

What more will you wonder?
The science and maths behind the exhibits

Wonderlab: The Equinor Gallery is packed with over 50 hands-on experiments and experiences. You need to look closer, ask questions and get creative to discover what they're all about.

If you're still curious you can find out more about the science and maths behind each of the exhibits using these handy resource packs. Check out each of the seven zones that you'll find in the gallery.

Sound

Sound can be experienced in many different ways. It always travels through a medium and can change in pitch and frequency. You can also make use of sounds to create music.

Find out more about the science behind the Sound zone exhibits in this pack.

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The science behind the exhibit

Sound Bite shows how we can hear sounds through our teeth and bones. Sound needs to travel through a medium, such as air, water or a solid. Normally we hear sounds when they travel through the air. The sound waves travel into our ear canal and cause our eardrum to vibrate. These vibrations are passed onto the bones in our inner ear. These in turn transfer and amplify the sound wave to the cochlea (a tiny organ in our inner ear). The vibration of the fluid inside the cochlea sends signals to the brain that we hear as sounds.

When you use Sound Bite you can hear sounds in a surprising way. If you bite down on the metal rod you can hear music playing through your teeth. This works because a hidden music device is connected to the ends of the rods and is playing music very quietly. The sound is much too quiet to hear normally through the air. However, as sound travels more easily through solids than through gases, it travels well through the solid rod.

When you bite the rod the sound waves travel through the rod and through your teeth and the rest of the bones in your skull. When the sound wave reaches your inner ear and cochlea it causes signals to be sent to the brain. We perceive this sound no differently to the sound we would hear if it travelled through the air as usual. This kind of sound perception is called bone conduction.

Normally when we talk we hear our own voice in two ways, through both bone conduction and through the air. When we talk sound travels through our teeth and bones. The lower-frequency (lower-pitch) vibrations travel better and are enhanced. This means that when we hear our voice on a recording we are only hearing the sound through the air. So our voice sounds much higher pitched on a recording than we are used to.

The science behind the exhibit

Echo Tube shows how sound can be reflected and heard as an echo. Sound travels through a medium such as air in the form of sound waves. When these sound waves meet a surface they can be reflected back to where they came from. Sound travels through air at 330 metres per second. This is very fast, but not as fast as light, so when a sound is reflected the delay can be heard as an echo.

If you look closely you'll see that in the Echo Tube there are two shutters at different positions in the tube: one in the middle and one at the end. Each of these shutters can be opened and closed. If a shutter is closed and you make a sound then it will travel down the tube and bounce back off the shutter. The sound travels back towards the opening and can be heard as an echo. It takes longer for the echo to be heard when the furthest shutter is closed than when the nearer one is closed.

If you listen carefully you'll find you can still hear an echo even when both shutters are open. This is because the air pressure inside the tube is higher than the air pressure outside the tube. When the sound wave meets the open end of the tube this change in pressure causes a wave to be reflected down the tube from the open end. These echoes sound slightly different to the echoes heard when a shutter is closed.

Echoes from the open ends of tubes are what makes musical instruments such as horns and trumpets work. When the sound wave reflects up and down the tube from the open ends, this creates standing waves inside the tube, which we can hear as a loud musical note.

The science behind the exhibit

When you touch the Pods you'll feel sound as well as hear it. Inside each of the Pods are hidden speakers that are making different sounds. Sound needs to travel through a medium, such as air. Every medium, including air, is made of molecules. Sound is actually caused by the movement of these molecules. The molecules get compressed together, making the molecules in front of them also get compressed, leaving an area of low pressure, called a rarefaction, behind them. The compressions and rarefactions travel through the medium as a wave.

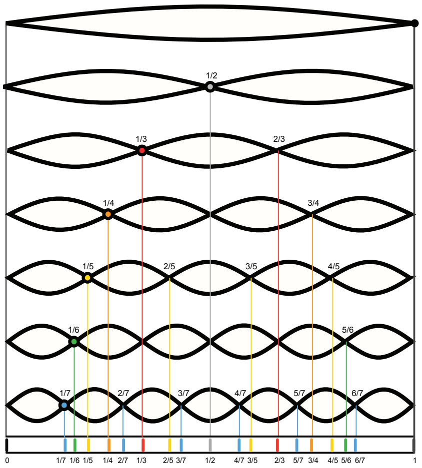
Sound can travel through solids, liquids or gases. The closer together the molecules of the material are, then the faster the sound wave travels. In air, where the molecules are far apart, sound travels at 330 metres per second, whereas in water it travels at 1,433 metres per second. In a solid it goes even faster – for example 5,130 metres per second in iron.

When the speakers inside a Pod produce sound waves these waves travel through the air, the surface of the Pod and back into the air. As the sound wave travels through the Pod it causes its molecules to vibrate. This vibration is strong enough that you can feel it when you touch the Pod. When the sound from the speakers changes in pitch or volume it also causes the sound wave to be different. This changes the strength and speed of the vibrations, and you can feel this too.

The science behind the exhibit

The Waves exhibit shows how wave patterns can change the sounds we hear. As the motors turn they cause the string between them to spin. The spinning string makes different wave patterns depending on whether the two motors are in sync with each other or not.

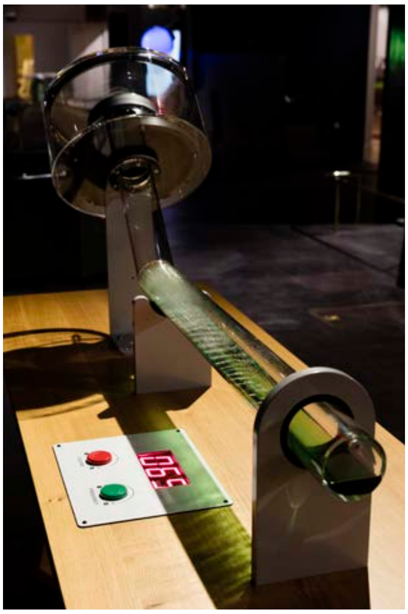
When the two motors are in sync the string makes a wave with a regular pattern. If the motors are spinning slowly at just the right speed they will make a regular wave pattern with only one peak. If the motors spin at multiples of this frequency the wave will have more peaks and troughs. These regular wave patterns are called harmonic waves.



Regular harmonic waves tend to produce louder, clearer sounds than irregular patterns. The irregular patterns change and move and don't tend to hold a distinct sound for very long.

These regular wave patterns resemble the harmonic waves seen in the vibrating strings of musical instruments. When you play a note on a guitar or a violin (by plucking or bowing a string) the string will vibrate in its own harmonic wave patterns. It is the combination of these harmonics that gives each instrument its distinctive sound.

The science behind the exhibit



Visible Vibrations lets you see sound waves and explore resonance. Most objects will vibrate if they are hit or disturbed in some way, such as being plucked or rubbed. When the object vibrates it will tend to vibrate at a particular frequency, or set of frequencies. This is called the natural frequency of an object. The natural frequency depends on the size, shape and elasticity of the object.

Sound travels as a wave through a medium, such as air, water or solid rock. This sound wave has a frequency and amplitude. Frequency is how high or low the pitch of the sound is. If the frequency of the sound wave matches the natural frequency of the object it will cause the object to resonate. This resonance means the sound wave vibrates through the material much stronger and we hear this as a louder sound.

Resonance is a complicated idea, but it can be illustrated with the idea of a child on a swing. The child will swing back and forth at a natural frequency. However, you can get them to swing even higher if you push them at this same frequency. You can do this if you push them when they are at the highest point of each swing. This is when you are at resonance and the child will swing very high. It doesn't work if you push them too often or not often enough.

If you listen closely you'll notice that some frequencies cause the sounds to become much louder. This indicates the sound is at a frequency that matches one of the natural frequencies of the tube, meaning it is at resonance.

When the tube is at resonance the oil also makes splashes. These splashes indicate standing waves. A standing wave happens when the sound wave bouncing down the tube reflects off the end and bounces back. This means there are sound waves travelling in both directions inside the tube. When the sound is at a resonant frequency these sound waves line up. The oil in the tube gets caught between the two sets of sound waves and appears to hover in the tube.

As the tube has several sets of natural frequencies there are many points when the tube can be at resonance. The standing wave will appear in different places and a different number of times depending on which resonant frequency is being used.

The science behind the exhibit

You can make music with our Theremin Bollards. As you move closer to or further from these two posts you change the sounds that they produce. By combining different sounds you can make music. The posts work using the same technology as a theremin, which is an electronic musical instrument.

Inside each of the posts is a hidden antenna and speaker. The antenna is able to pick up your position and this changes the sound signal produced by the speaker. The sound becomes higher in frequency and louder in volume the closer to the antenna you get. The sound also gets higher pitched as you move away from the bottom of the post and towards the top. This sound changes in a scale from low to high frequency.

You can use this to find different frequency sounds depending on how far you are from the posts. As the two antennas are producing slightly different types of sound, this means you can combine these different frequency sounds together to make music.