

SCIENCE MUSEUM

WONDERLAB: THE EQUINOR GALLERY

The science and maths
behind the exhibits

INFORMATION



Age
7-11
11-14

Topic

ELECTRICITY

 **30 MIN**

Location

LEVEL 3, SCIENCE MUSEUM, LONDON

Electricity

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.

Electricity

While they seem different, electricity and magnetism are very closely linked. Find out how they can be used to make an object float. Or experience electricity on different scales, from building a circuit to seeing bolts of lightning shoot across the ceiling.

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

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Electricity

Lightning Strike (12)

The science behind the exhibit



Lightning Strike lets you touch a tube with lightning inside. The tube contains a gas at low pressure and a metal model of an aeroplane. There is a high voltage of electricity passed into the tube from an electrode in the centre. When the voltage is very high like this it causes a strong electric field. This strips the electrons from the air molecules inside the tube and creates plasma, which is a soup of positive ions and negative electrons.

Plasma can conduct electricity, and when the charge flows through it this causes some of the molecules to become excited. When they return to their normal state they release this energy as visible light. We see this as the glowing streamers inside the tube.

The electricity will conduct through the plasma in the tube, both to the model plane and the glass, and from there into the ground. When you touch the glass tube you create a convenient route for the electricity to conduct through you and into the Earth. Luckily most of the voltage is insulated by the glass and so the current is tiny when it flows through you. As it is so small you can't feel a thing, but you still conduct the electric charge through you.

The metal aeroplane inside the tube can also conduct electricity. During a storm lightning can strike aeroplanes, but usually it is harmless. The people, electronics and fuel inside the plane are left unharmed because the metal shell distributes the electric charges around it. This leaves anything inside the shell unaffected by the electric charges. The electricity will exit through a different part of the plane and conduct down to the ground.

Electricity

Circuits (13)

The science behind the exhibit



The Circuits exhibits let you build and explore how electric circuits work. A circuit is formed when a loop of metal wire is connected to a power supply, such as a battery. When the two terminals of the battery are connected by the metal wire it causes an electrical current to flow. This current is made of negatively charged electrons flowing from the negative terminal of the battery to the positive one.

A circuit that only connects the two ends of a battery is not very useful and is also very dangerous because the current will be very high. Instead various components can be added to the circuit to control the flow of electricity. These components can make use of the electric current to power devices such as light bulbs, buzzers or motors.

Even though there are different components in the circuit the electrons still flow in a continuous path, providing they are all connected together in a complete loop and include a power supply. When more devices are added to a circuit they will have a lower power output if the power source isn't also increased. This means light bulbs will be dimmer and buzzers quieter.

When you add more than one battery or component to a circuit you can also change how they work depending on how you connect them together. Circuits set up as a series have only one path down which the electrons can flow, which means that if one component breaks then the whole circuit will be broken and any other components will stop working as well.

Another way to set up a circuit is in parallel. In a parallel circuit there are several routes that the electrons can take. So if one component breaks there is another pathway the electrons will take, which powers the other components.

Electricity

Floating Magnet (14)

The science behind the exhibit



Floating Magnet shows eddy currents, which are created because of the close relationship between electricity and magnetism. Eddy currents are circular electric currents that are induced inside a conductor by a moving magnet.

All magnets have magnetic fields. A magnetic field is the space around a magnet where it has influence and can attract or repel magnetic materials. A good conductor is usually a metal that contains lots of free electrons. These electrons help pass the electric charge through the material.

A good conductor isn't necessarily magnetic, though. Copper is a good electrical conductor, but it isn't magnetic. However, when a magnet is moved inside a copper tube the magnetic field can influence the free electrons inside the copper.

The magnetic field can cause the electrons to move in circular currents at right angles to the magnetic field. These small electric currents are called eddy currents. The eddy currents themselves also create a magnetic field. The two magnetic fields of the magnet and the eddy currents interact with each other and can cause odd effects.

If you look closely at the exhibit you'll see that these opposing magnetic fields can cause the magnet inside the tube to be both attracted and repelled at the same time. This exerts a drag force on the magnet inside the tube, making it move slowly towards the magnet on a string. As a result you should be able to carefully manoeuvre the inside magnet and get it to levitate. You can try to levitate the magnet inside the tube for as long as possible and move it up and down the tube without it hitting the sides.

Electricity

Magnetic Sculpture (15)

The science behind the exhibit



Magnetic Sculpture lets you explore how magnetic materials are attracted to magnets and how this can be used to build creative structures.

Magnets are objects that produce a magnetic field. This magnetic field is the invisible space around a magnet where the magnet has influence to attract or repel magnetic materials. Magnetic materials are objects that are attracted to magnets, such as iron, nickel, cobalt, the rare-earth metals and their alloys.

The metal washers used on our tree are made of steel, which is magnetic. If magnetic materials are brought within a magnetic field their atoms become aligned in the same direction as the field lines. When this happens they are attracted to the magnet and begin to become magnetised themselves. This means other washers can be attracted to it.

When the washer is removed from the magnet its atoms will become misaligned again and it will lose these magnetic properties. However, the longer that the washer is exposed to the magnetic field, the longer these properties will last.

The washers can be used to build branches or chains on the magnets on the tree. However, when chains from two different magnets are brought together this can cause both chains to fall apart. This is because the two magnets may have different orientations of their magnetic field. These two magnetic fields will oppose each other and can repel the washers, making them all fall off.

Electricity

Electricity Demo Area (16)

The science behind the exhibit



During the Electricity Demo Show you'll see both a tesla coil and a Van de Graaff generator in action. These are machines that accumulate electric charge.

The Van de Graaff generator works by rubbing two materials together, which causes positive charge to build up in the dome. When a negatively charged or neutral object gets close to the dome the charge will conduct between them, which we see as a spark of electricity.

The tesla coil also builds up electric charge but in a different way. It stores up electric charge inside two capacitors. The charge will flow between the two capacitors so that it gets amplified up to a very high voltage. Eventually the charge is great enough that it will conduct through the air as a visible spark or bolt of lightning. When there are rings around the coil the lightning will arc onto these.

What is a bolt of lightning made from?

Lightning is a discharge of electricity as plasma. When the electric charge first builds up inside the tesla coil or Van de Graaff generator it causes an imbalance of charge between the machine and its surroundings.

The charge can't move because the air around it is a good insulator, which means electric charge can't conduct through it. So the charge keeps building up higher and higher. As the electric charge builds up it causes the electric field around it to become stronger.

The electric field then begins to ionise the air, stripping the atoms in the air of their electrons. This turns the air into plasma, which is a soup of positive ions and electrons that can conduct electricity. When the charge is great enough it will conduct through the plasma. As the charge travels through the plasma it excites the ions along its path.

When these ions then return to their normal state they release this extra energy as light. This means we can see the pathway of the electric charge as the excited plasma – or as we better know it, a lightning bolt.