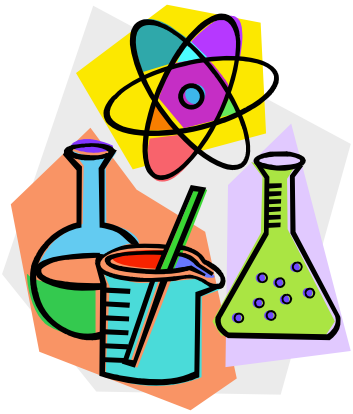
The Science of Bells



Like mathematics, Science is everywhere. Let's look first at just some of the science involved in the ringing of bells.

Much of ringing a 'change ringing' bell is about energy and the controlling of forces and can be looked at in terms of what scientists call **Mechanics,** which is the study of the motion of objects resulting from the forces acting on them.

Many forces are applied to the ringing bell such as gravity and the ringer pulling the rope as well as energy being **transferred**.

We first need to understand what scientists mean by the words **Energy, Force** and **Work.**

Think of **Force** as a push or pull, something that changes the motion, size, or shape of an object. In order to make a ball move you have to push or pull it. If you push a ball down on the floor it changes shape. In both cases, you have applied a 'force' to the ball.

The **work** we are talking about here is work in the physics sense. Not home work, or chores but what is called **mechanical work**.

Work is energy that has been used. When you do work, you use energy. Energy is a *measure of* how much work we can do.

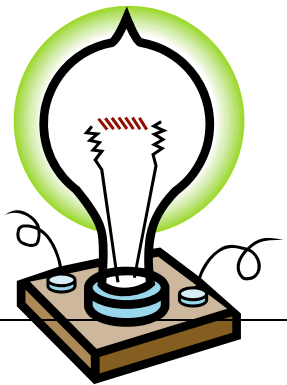
There are two kinds of energy: **potential** and **kinetic**.

Potential energy is *waiting to do work*. Petrol in a fuel tank, food in your stomach, a compressed spring, and a weight hanging from a tree are all examples of potential energy.

When you lift an object higher, it gains potential energy. The higher you lift it, and the heavier it is, the more energy it gains. For example, if you lift a bowling ball 1 cm, and drop it on the roof of a car, it won't do much damage (please, don't try this). But if you lift the ball 10 metres and drop it on the car, it will put a huge dent in the roof. The same ball dropped from a greater height has much more energy. So, by increasing the height of an object, you increase its potential energy.

Kinetic energy is *energy of motion*. Objects that are moving have kinetic energy. If a car crashes into a wall at 1 kph, it shouldn't do much damage to the car. But if it hits the wall at 60 kph, the car will most be severely damaged because of the greater kinetic energy it possesses.

One of the basic laws of Mechanics says that energy cannot be created or destroyed, but it can be changed or **'transformed'** from one energy to another. Forms of energy include mechanical, electrical, chemical, heat, light and sound.



Energy can be readily transformed from one form into another. Potential (or stored energy) for example chemical, elastic) may be converted to kinetic energy (for example electrical, mechanical) and from kinetic energy to heat, light or sound energy. For example, using a battery to power a light globe converts chemical energy into electrical energy, which is then converted into light and heat

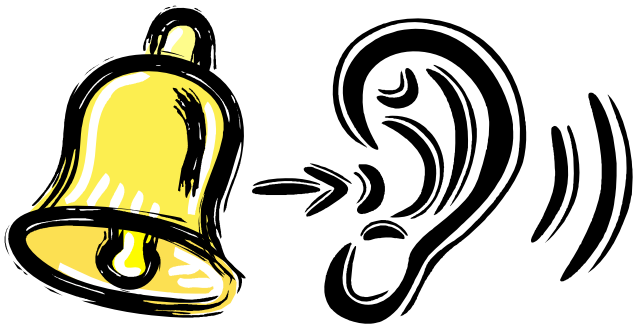
Because the bell is attached to an axle (called the Headstock), the movement of the bell is circular rather than in a straight line and this is called **Rotational Motion**.

When a bell is rung 'full-circle' it begins in the up position resting on its stay and slider. In this position the bell has its maximum potential energy.

The ringer then carefully applies a force to the bell by pulling the rope to bring the bell past its balance point and the bell begins its spin or **rotation**, potential energy is converted to kinetic energy and the bell swings quickly through its rotation.

The ringer controls this rotation as the rope wraps around the bell wheel and as it reaches this upright position again it slows increasing its potential energy. The ringer then applies a force by pulling down again on the rope to rotate the bell in the opposite direction. As the bell approaches the upright position, the clapper strikes the bell and makes the ring sound. Check this out when you watch the bells on level 4.

Although you don't have the skill and experience to ring full-circle, it is possible for people without ringing experience to **chime** a bell (which is hung 'down") during a demonstration at the Swan Bells. It still involves you using your chemical energy to supply your muscles to pull the rope converting it to kinetic energy which is transferred to the bell. The bell then hits the clapper to produce sound energy.



So the bell moves, the clapper strikes the bell and some of the kinetic energy is transformed into sound. Sound is a form of energy produced by vibrations that travel through air and we are able to hear. Scientists have called the science of sound, **Acoustics.**

When the clapper strikes, the bell begins to move quickly back and forth or **vibrate** and push the molecules in the air back and forth to form sound 'waves'.

Sound needs a **medium** to travel through, such as air which is made up of molecules that vibrate and **conduct** the sound. In the same way as a bell strikes and vibrates (although hopefully not as loud), when you speak the vocal cords in your throat vibrate and transmit these vibrations into the air where they picked up by your and others ears and are heard as sound.

Not just gases such as air conduct sound. Liquids and solids are even better mediums for conducting sound. Animals that live in the ocean such as whales and dolphins can communicate over large distances because water is a good conductor of sound.

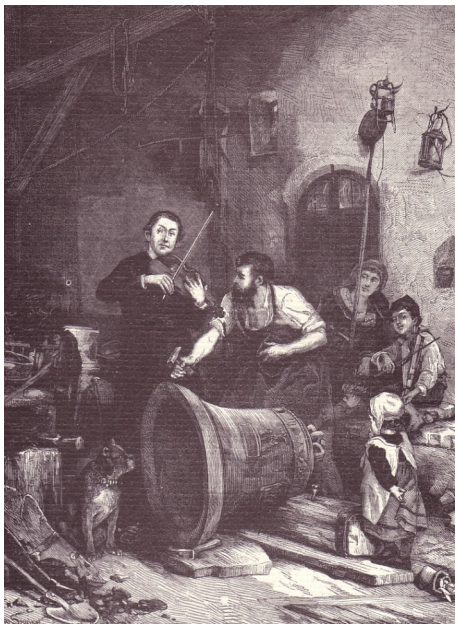
When we listen to a sound, one of the ways of describing it is its **'pitch'** or how 'high' or 'low' the sound is. Another word for pitch is **frequency**. The frequency of the sound is the number of sound waves that pass by in a second and is measured in **hertz**, which is the number of waves passing every minute. High notes have a high frequency and a high number of hertz; they have a lot of vibrations or many waves per second. Low notes have a low frequency and a low number of hertz.

You will notice listening to the bells that the smaller the bell the higher the pitch and the larger the bell the lower the pitch. Larger objects usually have a lower natural frquency. You can hear this when you compare the sound of a violin and the sound of a double base in an orchestra.

You can demonstrate this effect with water in jars. The larger the volume of water in the jar the lower the note will be produced when you tap the jar with with a pencil.

Most people think that bells have one note but in fact they can produce several and this gives them that 'bell-like' sound.

These days bells are tuned using a machine that removes metal from inside the bell and the frequencies produced by the bell are measured electonically. Before this technolgy bells were tuned using a bellfounders ear to compare the bell with notes on a violin or tuning fork. The notes were adjusted by chipping metal from the lip of the bell. Careful!



You can see chipping on several of the St Martins bells if you look carefully as well as the modern shaving marks on the inside of the bells.

So here are just a few ideas about the science of ringing. I'm sure you can think of many more. In the meantime if you get the chance, listen and enjoy the sounds of the Swan Bells.

Link to the Curriculum Framework

Learning Area: Science

Strand: Understanding Concepts

Substrand: Energy and Change

EC3 The student understands patterns of energy use and some types of energy transfer.