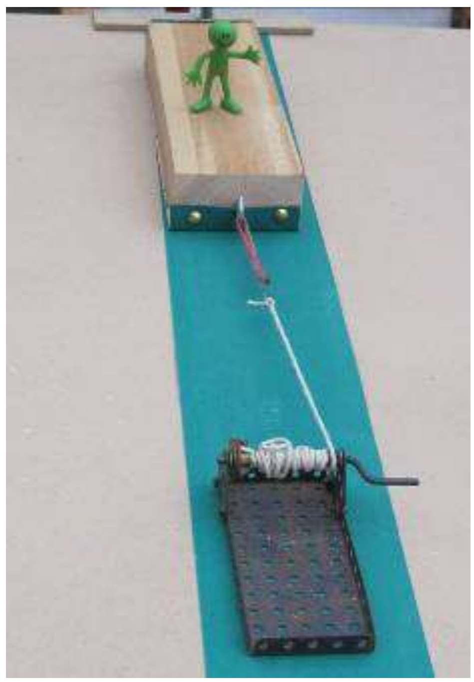
Earthquakes

The cause of sudden movements **D**

To show why the movement along a fault is not smooth and continuous use the following apparatus: a block of wood 30cm by 10cm by 5cm with sandpaper pinned to it and a hook in one end which is placed on a strip of sandpaper 1m long. An elastic band is attached to the hook on the block and a piece of string is tied to the end of the elastic band. The string is wound onto a winch. A toy person is placed on top of the block. Students wind the string up as slowly as possible trying not to cause the toy to fall over.



Factors controlling the size of the throw **D**

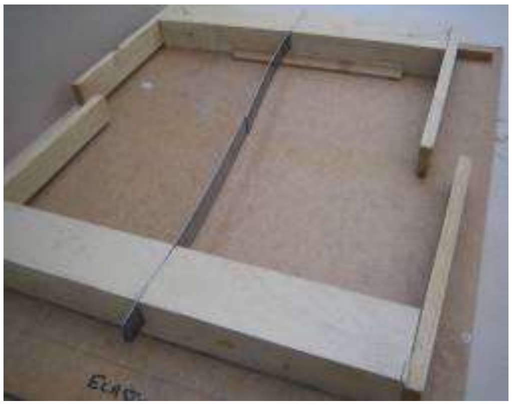
Use the apparatus above to aid discussion into the effect of speed of crustal movement, roughness of fault surface, pressure pushing the two sides of the fault together and the compressibility of the crust.

Snapping fingers ***A I 1 min***

Students snap their fingers to show how movement is initially prevented by friction and is then followed by a sudden movement.

Elastic rebound ***D***

Two steel rulers mounted opposite each other in blocks which can move sideways. The rulers just overlap. One block is held stationary while the other is moved. Initially the rulers deflect and then with further movement they part and become straight again but offset.




Elastic rebound using fingers ***D***

Your hands represent the line of a railway. Hold your hands horizontally with one palm facing up and the other down and press your finger tips together. Hold your hands horizontal and press the tips of your fingers tightly together. Keeping your arms horizontal move the arm with the palm facing up upwards. Your fingers should now be bent. Further upward movement of the arm will result your fingers parting and straightening out.

Types of waves ***D***

To show P and S waves a double slinky is stretched out with a tab of brightly coloured paper attached half way along. Move one end quickly forwards in the direction of the coil. This will generate a P wave. The longitudinal motion of the particles can be seen by watching the paper tab. Stretching the spring will speed up the wave (= rocks which are less compressible)

Shaking one end will create S waves and the paper tab shows the sideways motion of the particles.

Role play P and S waves ***G 10 min***

Students line up with their hands on the shoulders of the person in front. The teacher gives the rear student a shove and a P wave passes down the line. Next the students form a row all facing sideways with linked arms.

The teacher gives the end person a push from behind and an S wave passes down the line.

Generating P and S waves — *D*

To show how both P and S waves can be generated by a single movement connect 4 slinkies to each side of a box using bull dog clips. The box rests on a table and the other end of each of the slinkies is held by a student. A sudden movement of the box will generate S waves in one direction and P waves at right angles. Of the P waves a compression wave arrives first on one side and a dilation on the other.

Long waves — *D*

A transparent water trough can be used to show how L waves die out at depth. Use a pipette to inject a dot of food colouring at different depths.

Create some gentle waves. The deeper dots will not be affected by the wave motion.

Pond analogy of Richter scale — *TE*

Imagine someone is dropping pebbles into the centre of a pond. The height of the ripples is measured at a fixed distance from the centre. The height will vary with the size of the pebble (energy imparted).

Refraction of waves using a ripple tank — *D*

Place a circular disc representing the earth's core in a large shallow tank of water. The wavelength and direction of the ripples will be modified as they pass over the disc.

Whole earth vibrations I — *D*

When there is a large earthquake the whole earth vibrates like a bell, London actually going up and down 1m but very slowly. This is a fun and very noisy way to illustrate this. An old circular saw blade 60cm in diameter is suspended on a string. Students tap the blade with a hammer and then put their fingers on the surface to feel it vibrating.

Whole earth vibrations II — *D*

Squeeze and then stretch a hula-hoop to show one of the ways that the earth changes shape during a large earthquake as it vibrates.

Shock wave *A P 2 min*

To show the very small movement involved in a shock wave put three coins e.g. 2p pieces side by side and touching. Press down very hard on the middle coin or hold it in place with a G clamp. Now use your other hand to flick an outside coin at the pressed down coin. The coin on the far side will shoot away because the shock wave is transmitted through the middle coin. A Newton's Cradle shows the same thing.

Cause of vibrations *A P 1 min*

Students place a ruler over the edge of a desk, deflect it and let it go. The ruler does not simply return to its initial position but vibrates. The particles moved by the seismic shock wave do the same

Inertia *A P 3 min*

Place a piece of wood 7cm by 3cm by 1.5cm end on onto a piece of A4 paper so that it is like a skyscraper. Pull the paper sharply. Which way does the wood fall? Now examine a photo of a chimney which fell during an earthquake and suggest which way the land moved and why.

Inertia, movement and resonance *D or P 5 min*

To show how a pendulum can record the movement of the earth even though the earth is itself moving and how it may magnify the movement, a fishing line weight (no 3 or 4), a heavy nut (100g), or other object is tied to the end of a metre long piece of string. Hold the end of the string with the nut just above the floor and move it very slowly. The string should remain vertical. Now move it much faster for a distance of 10cm and then stop. The nut initially stays still and then moves.

It is possible to move the string backwards and forwards so fast that the nut does not move. Imagine now that your hand is the earth moving we could record the motion of the earth with reference to the nut.

By experimenting you can find a speed of backwards and forwards movement over a short distance which causes the nut to swing over a larger distance, this is the period of resonance.

Pendulum on a retort stand *D*

Another way of showing how the shaking of the earth can be recorded even though the earth itself is shaking is to use a tall (60cm minimum) retort stand. This labelled is "the earth". A weight is hung from an arm *attached to the retort stand. It can be used in the same way as the pendulum in the description above in "Inertia, movement and resonance". If the weight is cylindrical, a pen can be attached to it. But it is better to attach a 15cm piece of 13mm diameter copper tubing and to put a pen put inside the tubing. The pen can then slide up and down and always be in contact with the paper. Students can then see how the friction of the pen affects the movement.*

How a modern seismometer works **D**

This demonstration is show how the movement of a magnet in a coil generates and electric current and how this can be used to measure the shaking of the earth. You will need a 15cm bar magnet and a 10,000 turn coil connected to a microvoltmeter. First demonstrate the generation of current by moving the magnet in the coil. Then hang the magnet by a nylon thread from a retort stand so that it is within the coil. Tapping the bench will generate a current.

Idea from Keith Moseley

Vibration detector **D**

To demonstrate how the amplitude is determined by distance or by strength of shock wave use a vibration detector (obtainable from Teaching Resources Ltd 01992 716052) and a computer on to which Audacity has been downloaded. Place the detector on a concrete floor. Drop onto the floor different weights to see the effect on the amplitude of the waves. Alternatively drop the same weight at different distances.

A modern seismometer *D*

The seismometer sold by Middlesex University Teaching Resources but available free to British schools can be used to show students what a seismometer looks like and how it works. It can be connected to a computer with Audacity software. When the bench is tapped the vibrations will show on the computer screen. Or it can be placed permanently on a concrete floor and will record earthquakes anywhere in the world which are greater than 6 on the Richter scale. Traces of any recording can be placed on the display screens around the school. For a free seismometer contact Paul Denton at the British geological Survey.

Triangulation *D*

To illustrate how small movements along a fault are detected use two blocks of wood 15cm by 10cm by 3cm. 2cm nails are hammered half in on the long edge of one block and one nail half way along the edge of the other block. The blocks are placed together and a tight elastic band is placed over the nails. Movement results in a lengthening of one distance and a shortening of another, while the distance between the two nails on the same block remains constant as reference. This is important because air temperature affects the distance measurements.

In case of an earthquake *D F*

In some earthquake prone areas there are signs in hotel rooms just as in England there are for fire. I have this one pinned on my classroom wall.

Measuring how far away an earthquake is *TE*

Everyone knows about using the lag time between the arrival for the lightening flash and the thunder to work out how far away the lightning strike was. Using the lag time between the arrival of P and S waves uses the same principle. Using the idea of two students running at different speed is also helpful; 2 min behind after 1km, 4 min after 2km, how far have they run if the one student arrives 16 min behind the other?

Locating a British earthquake *Pa I [F](F) 15 min*

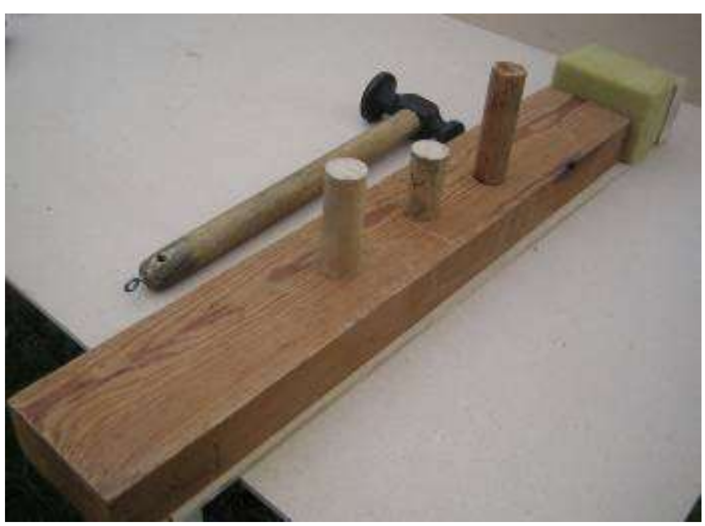
Students are given seismograms for 4 stations located in the British Isles. They must read off the arrival times of the P and S waves, work out the distance of the focus from each station and then use compasses to locate the focus on the map.

Isoseismal lines for a British Earthquake *Pa I [F](F) 10 min*

Students use the spot measurements of intensity on the Mercali scale to plot isoseismal lines for an earthquake in Wales.

Stability of buildings *A P 5 min*

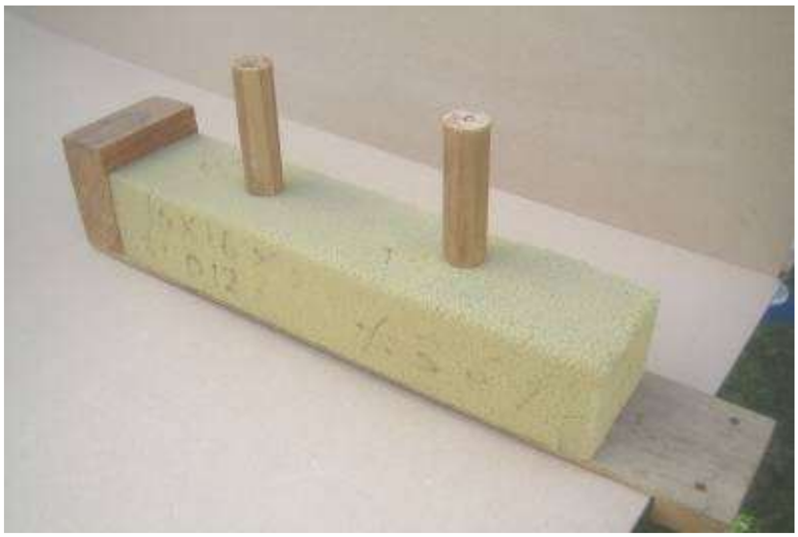
To show the effects of height and diameter on stability you will need the things shown in the photo: wood block 50cm by 10cm by 5cm, piece of sponge, wooden block clamped to table, hammer, several pieces of dowelling of different diameters and lengths. Place the pieces of dowelling on the long piece of wood and tap the end with the hammer to see which are most likely to remain standing.



Dissipation of energy with distance **A P 5 min**

To show that the energy of the shock wave decreases with distance.

A piece of sponge 10cm by 10cm by 40cm with one end placed against a wall or so that it can not move. 2 pieces of dowelling 3cm in diameter and 10cm long are placed at intervals on top of the sponge. Generate a shock wave by hitting the free end of the sponge and see which piece of dowelling falls over.



Base isolation **A P 5 min**

To illustrate one method of isolating a building from the effects of an earthquake you will need the same apparatus as in "Stability of Buildings" above plus two pieces of doweling 3cm diameter and 10cm long, and 10 squares of acetate (e.g. OHP transparency) about 5cm by 5cm.

Place the pile of acetate on the long block of wood, place one cylinder directly on the wood and the other on the acetate. Tap the end of the long block of wood. The one on acetate should stay standing.

Subsidence *A P 5 min*

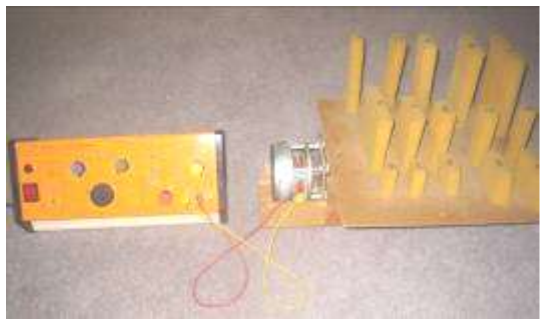
To show how shaking can cause buildings to subside use A 2 litre jug filled with dry sand and a steel block 5cm square by 1cm thick or better a house shape made of steel.

Place the jug on an A4 piece of paper on a table. Place the steel on the sand. Students should try to press it into the sand. Providing they press evenly it will not go into the sand. Then they move the jug backwards and forwards quickly on the paper. The steel sinks.

The swaying of buildings *D*

This is to show how tall buildings sway in an earthquake and engender discussion of how this might be prevented by for instance base isolation or cross bracing or ensuring that the resonating frequency is different from *the vibration frequency of most earthquakes. Glue the end of a piece of polystyrene foam 10cm by 10cm by 60cm onto a board 15cm by 15cm. The board rests on a table and is pushed backwards and forwards a various frequencies to find when it resonates.*

The effect of earthquakes on buildings *D F*
To show how buildings of certain dimensions will resonate and thus exaggerate the earth movement and that it is not necessarily the highest buildings which are damaged.



Earthquake *E P F 60min*
In this experiment students simulate an earthquake and investigate the relationship of fault displacement to friction, compressibility, and frequency of movement.

Recurrence interval *Pa I F 15 min*
Students plot data from a number of earthquakes and then use the resulting chart to work out how often one can expect an earthquake of a given magnitude.

Power Law *Pa I F 10 min*
Students plot magnitude against the log of the number of earthquakes each year of each magnitude to see that it produces a straight line.

Earthquake sounds *D*
The Seismological Society of America produces a tape recording of the sounds made by a variety of earthquakes.

Tsunami height *Pa I 5 min*
To illustrate the height of the tsunami that was generated by the 1964 Alaskan earthquake, students draw a line on graph paper to represent the

height of the wave, 67m and then beside a line to represent the height of an adult of 1.7m.

Which faults cause tsunamis? **D**

On Boxing Day 2004 an earthquake, 9.1 on the Richter scale struck Indonesia causing a massive tsunami. Other powerful earthquakes, 8.7 and 8.6 struck the area in March 2005 and more recently in April 2012 but caused no tsunami. The Boxing Day earthquake was caused by movement on a thrust fault and the latter two by movement on wrench faults.

Cut two wooden blocks made from pieces of wood 30cm by 10cm by 5cm and cut at 60º and 30º and shaped as illustrated below. Use them to show that movement on normal and thrust faults will change the level of the sea floor and thus cause tsunamis, but that a wrench fault movement will not alter the level of the ocean floor and not create a tsunami.

Making a tsunami **D**

To show the formation a tsunami and how the wave height changes with water depth and use a glass tank 2m long with sloping bottom. A brick attached to a string is placed in the deep end. Pull the brick up suddenly and watch the wave as it travels to the shallow end, gets steeper and asymmetrical and then breaks. Water will get spilt. Make a V shape in the shallow end to show how the height of the tsunami is increased in a bay.

Quake cake **D F**

A cake which has been cut in two rests on two boards. The cake is iced over to cover the junction. Liquorice Allsorts, representing buildings, are placed on the surface. When the boards are moved the buildings fall over. Good for birthdays.

Cities and earthquakes ***Pa I F 45 min***

Students plot the positions of all cities with a population of more than 3 million on a seismic map of the world.