Prediction of Earthquakes – 'Brickquake'

a) a qualitative 'brickquake' demonstration

Activity:
This activity provides a simple demonstration of the build-up of stress as house bricks are pulled over each other, using an elastic rope, in the same way as stress builds up and is released suddenly in earthquakes.

Carry out a risk assessment (see page 70 at the end of this document).

The bricks are set up with two in line, with two more on top of the rear brick. String is tied round the middle brick in the 'tower'. Explain that this represents two vast rock masses which will come under stress until they start to slide over or past each other. This is what happens in an earthquake.

The front brick should either be held by hand so that it does not move, or restrained by a clamp, as in the photograph.
Gradually increase the tension on the elastic rope attached to the string, until the bricks begin to move. Ask the students to predict at what point this will happen if the activity is repeated and then carry out several runs. The point at which the bricks move is seldom exactly the same as any previous run, either in terms of time taken to apply the tension, or the extension of the elastic rope. This is akin to earthquakes, where it is rarely possible accurately to forecast when a tremor will occur by studying strain gauge data or by judging the interval between seismic events.


Making a 'brickquake' © Peter Kennett

Watch out for bricks falling onto the floor.

Student learning outcomes:
Students will be able to:
- describe how tension increases until the brick suddenly moves;
- explain how this related to similar processes causing earthquakes.

Student practical or teacher demonstration:
Teacher demonstration

Time needed to complete the activity:
10 minutes

Preparation and set-up time:
4 minutes

Resources:
- 4 clean house bricks, (one with string tied around it end to end)
- Newton meter, (e.g. 50N)
- elastic 'bungee' about 40 cm long (e.g. luggage bungee)
- G-clamp
- ruler

b) a quantitative 'brickquake' demonstration

Activity:

As the Earth's plates move, friction 'sticks' them together at the edges and they bend slightly under pressure. Eventually the pressure is so great that a break occurs and the rock springs back elastically, causing an earthquake.

The brick 'earthquake' shows that energy is dissipated with a jog motion. By repeating the experiment, the distribution of jog distance and maximum force applied immediately prior to failure can be found.

If the distance moved by the brick each time it slips is recorded, a histogram can be plotted to show frequency for each size of slippage. An approximation of the relative energy released can be calculated using the equation: Force x Distance = Energy Transferred. This can be compared with a histogram showing the frequency of different magnitude earthquakes.

Brickquake, pulled by hand
© ESEU

Brickquake, pulled by a winding mechanism
© ESEU

Carry out a risk assessment (see page 70 at the end of this document).

The bricks are set up with two in line and the third one on top of the rear brick, just overlapping the gap. Its edge is marked on the lower brick, so that the distance moved can be measured. String is tied round this brick. The other end of the string is tied to a bungee which is connected in turn to a Newton meter and winding mechanism as in the diagram (if you have no winding mechanism, the Newton meter can just be pulled by hand, in as controlled a manner as possible).

The two lower bricks must be held firmly by blocks, clamps, or your hand.

A tray of water is put next to the lower bricks. A laser pointer is pointed at a shallow angle to the water surface so that the beam is reflected on to a screen or the ceiling and will make ripples in the water easier to see. A slinky spring can be fastened with tape under the table hanging down until it reaches the floor (optional).

The string is wound onto the winder, or pulled by hand. The measurement on the Newton meter is noted at the moment the brick moves. The distance moved by the brick is measured in metres.

When the brick moves, any motion of the water surface, magnified by the laser beam, and slinky spring are noted.

Optional: A fourth brick can be added to the top of the apparatus and the experiment repeated to find out how the results differ.

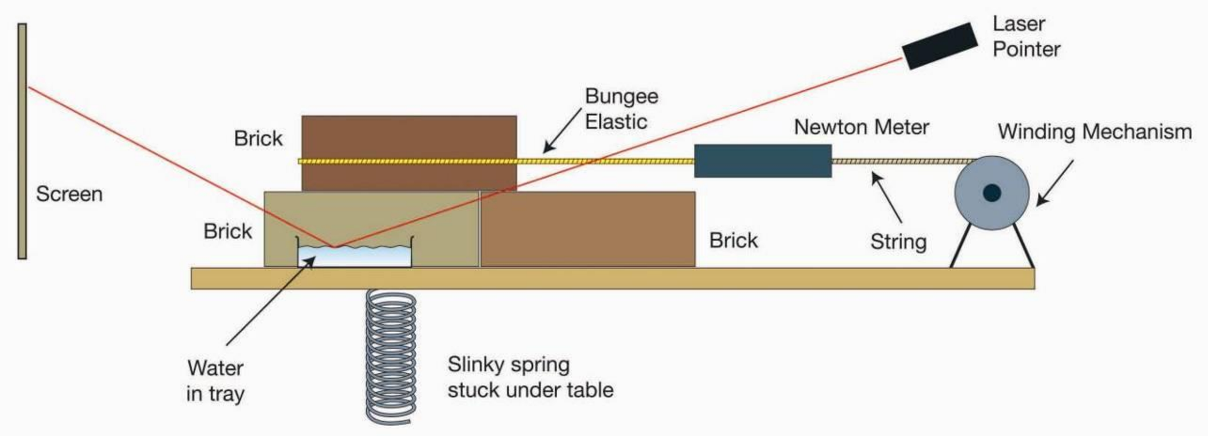

Diagram of apparatus for Brickquake © ESEU

Notes:
For safety reasons, position the audience to one side so that they are out of the way of the laser beam. Be wary of bricks falling on the floor, or someone's toes.
This activity is best done on a free standing table rather than a fixed bench so that it shakes more effectively.

Results expected:
Surface waves will be seen in the tray at the side. Body waves (P- and S-waves) will be seen in the slinky spring.
The brick will move smoothly once started or in discrete jogs. The chart below gives some actual results from the above activity and illustrates that although it may be possible to forecast an 'earthquake' it is not possible to predict the energy released.

Distance moved Meters (m)	Force Newtons (N)	Relative Energy transferred Joules (J)
0.02	15	0.30
0.075	45	3.375
0.035	35	1.225
0.04	25	1.00

Earthquakes generate three sorts of waves, two sorts of body waves (that pass through bodies –
S- and P-waves) and also surface waves. The S-waves are transverse waves (shear, shake or secondary waves (secondary because they arrive after P-waves)). The P-waves are the longitudinal body waves (primary, push-pull, pressure). Surface waves are caused when P- and
S-waves interact with the surface, and cause the most damage in earthquakes.

The magnification of the effect of the seismic waves by the laser pen reflecting off the water surface is a mechanism similar to that used in early seismometers to magnify shock wave traces.

Student learning outcomes:
Students will be able to:

- describe how 'earthquake' ruptures transfer energy to the surroundings in all dimensions;
- plot histograms of maximum force and slippage size and relate to different magnitudes of earthquakes;
- explain how difficult it is to predict exactly when an earthquake will occur and how big it will be.

Student practical or teacher demonstration:
Teacher demonstration mainly, or could be student practical, dependent on numbers and resources.

Time needed to complete the activity:
20 minutes

Preparation and set-up time:
20 minutes

Resources:

- 4 clean house bricks
- string, about 3 m long
- elastic ‘bungee’ about 40 cm long
- a range of Newton meters (e.g. up to 50N)
- laser pointer (or torch if laser pointer not available)
- a shallow tray containing water
- a winding mechanism (e.g. pulley block) clamped to the table with a G-clamp (optional)
- slinky spring (optional)
- sticky tape (optional)

Ideas for leading into the activity:
The effect of earthquakes may have a worldwide impact (e.g. 2004 Boxing Day tsunami) but what is the underlying physics? This activity simulates earthquake movements and illustrates that energy is transferred.

Underlying principles:
Explain that this represents two vast rock masses which will come under stress until they start to slide over or past each other. This is what happens in an earthquake. The ‘earthquake’ initiates forced oscillations of both P- (longitudinal) and S- (transverse) waves.

Ideas for following up the activity:
Carry out a web search into the frequency of earthquakes in known earthquake areas, e.g.
http://tsunami.geo.ed.ac.uk/local-bin/quakes/mapscript/home.pl

Extension ideas for more able or faster students:
Investigate variations using more bricks in different arrangements e.g. piled on top of each other to discover the effect of increased vertical pressure. This relates to earthquakes generated at different depths within the crust.

Other variables can be changed, such as variations to the surface on which the bricks move.

Source of activity:
Earth Science Education Unit.